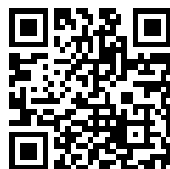

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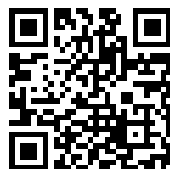
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PROCEEDINGS
OF THE
ROYAL PHILOSOPHICAL SOCIETY
OF GLASGOW

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OF GLASGOW

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1905-1906

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CONTENTS OF VOL. XXXVII.

	PAGES
Glasgow University Expedition to observe the total Eclipse of the Sun on 30th August, 1905. By Henry A. Mavor, Vice-President,	I-14
Saint Serf's Priory in Lochleven. By F. J. Amours, B.A., Officier de l'Instruction Publique, President of the Historical and Philological Section,	15-28
Elberfeld System of Poor Relief. By the Rev. Andrew Miller, M.A.,	29-37
Some Facts and Theories connected with the Inactive Gases of the Atmosphere. Lecture under the Science Trust. By Sir William Ramsay, K.C.B., F.R.S.,	38-45
Social Reformation of Criminals. By Bailie John Bruce Murray,	46-58
The Necessity for Improved Ventilation of Buildings. By Neil Carmichael, M.A., F.F.P.S.G., Examiner in Public Health, and State Medicine, Faculty of Physicians and Surgeons, Glasgow,	59-73
Notes on certain parasitic protozoa from the groups of the Myxosporidia and Hæmosporidia. By Muriel Robertson, M.A., Carnegie Research Scholar,	74-79
Social Derelicts; or the Contribution of the Army to Human Wastage. By John S. Samuel, J.P., F.R.S.E.,	80-92
The Eyesight of School Children: being a record of the examination of over 3,000 school children. By W. B. Inglis Pollock, M.D.,	93-124

774242

	PAGES
Heusler's Magnetic Alloys. By J. G. Gray, B.Sc., Secretary of the Mathematical and Physical Section,	125-128
On the Development of the Great Axial Lines of Folding in the Highland Schists. By Peter Macnair, Curator of the Natural History Collection in Kelvingrove Museum. Joint- Honorary Secretary of the Glasgow Geological Society, and Assistant-Lecturer on Geology and Mineralogy, Glasgow Technical College,	129-135
Some Notes on the leaves of <i>Nephrodium Filix Mas. L.</i> , and <i>Scolopendrium Vulgare Sm.</i> , in relation to Environment. By Janie Hamilton M'Iroy, M.A., B.Sc., M.B.,	136-141
 Some Early Grammars and other School Books in use in Scot- land more particularly those printed at or relating to Glasgow. By David Murray, M.A., LL.D.,	142-191
Solutions of Physical Problems. By Andrew Gray, LL.D., F.R.S., Professor of Natural Philosophy in the University of Glasgow,	192-239
Rules Governing the Competition for the Graham Medal,	240
Minutes of Session,	241-262
Office-Bearers of the Society,	263
Office-Bearers of the Sections,	264-265
Committees appointed by the Council,	266
Additions to the Library,	267-272
Exchanges with other Societies,	272-279
List of Periodicals,	280-282
List of Members,	283-299
Index,	300-303

PLATES.

PLATE	FACING PAGE
I.—Certain Protozoa,	78
Fig. 1. Trypanosoma pythonis, n.sp., showing blepharoplast close to nucleus.	
Fig. 2. Trypanosoma pythonis, showing blepharoplast remote from nucleus. This is the position most usually seen.	
Fig. 3. Trypanosoma pythonis, blepharoplast divided into two, and joined by fine fibril.	
Fig. 4. Trypanosoma pleuronectidum, n.sp., showing nucleus, blepharoplast, and vacuoles.	
Fig. 5. Trypanosoma pleuronectidum, n.sp.	
Fig. 6. Parasite in erythrocyte of plaice, showing nucleus (the membrane is absent), vacuole and centrosome.	
Fig. 7. Parasite of plaice. This individual happened to be free in the plasma, nucleus with membrane, vacuole and centrosome to be seen.	
Fig. 8. Parasite of plaice, large granular form, possibly a macrogamete, large nucleus and vacuole present, centrosome apparently absent.	
II.—Great Axial Lines of Folding. Map,	134
III.—Leaves of Nephrodium Filix Mas. L., etc.,	140
Fig. 3.—Drawing, under camera lucida, of stomata on under surface of leaf of sun-form of Nephrodium.	
Fig. 4.—Ditto of shade form.	
Fig. 5.—Tracing under camera-lucida of the sclerenchymal cells at midrib in the sun form of Nephrodium.	
Fig. 6.—Ditto of shade form	
Fig. 7.—Drawing under camera-lucida of the transverse section of leaf of Nephrodium grown in exposed situation.	
Fig. 8.—Ditto of shade form.	
Fig. 9.—Drawing under camera-lucida of sun-form leaf of Scolopendrium.	
Fig. 10.—Ditto of shade form.	

PROCEEDINGS
OF THE
ROYAL PHILOSOPHICAL SOCIETY
OF GLASGOW

SESSION 1905-1906.

Glasgow University Expedition to observe the total Eclipse of the Sun on 30th August, 1905. By HENRY A. MAVOR, Vice-President.

[Read before the Society, 1st November, 1905.]

THIS Expedition was organised at the instance of Dr Becker, Professor of Astronomy in the Glasgow University, who was asked by the University Court to observe the Eclipse. It consisted of Dr Becker, Mr J. Franklin-Adams a distinguished amateur astronomer, his son Mr J. Bernard Franklin-Adams, and Mr H. A. Mavor.

The original intention was to observe the Eclipse from the north of Spain, but an invitation having been conveyed to the Expedition from Mr Andrew Crookston, whose mines at Kalaa es Senam in Tunisia (Lat. $35^{\circ} 45' 3''$, N. Long. $33^{\circ} 30'$, East of Greenwich) are situated near the central line of totality, and at an elevation of of about 3,000ft. above the sea level, it was decided to adopt this position as likely to be more favourable on account of the high elevation and the expectation of less interference with the observations by clouds.

On consideration of the various methods of reaching the objective, the choice was made of proceeding as far as possible by sea so as to save handling and trans-shipment of the apparatus, which was contained in 13 packages weighing in all about $3\frac{1}{2}$ tons.

The Expedition sailed from London on the 11th August by the Peninsular & Oriental Company's steamer "Caledonia," and on the 17th August arrived at Marseilles, where the apparatus was trans-shipped to the S.S. "Ville d'Oran" of the Compagnie Transatlantique. The P. & O. Co. were good enough to carry the apparatus as passengers' baggage without charge, and the Transatlantic Co. also made a very material concession on their ordinary rates of transport.

VOL. XXXVII.

A

The "Ville d'Oran" sailed at noon on the 19th August, arrived at Philippeville in Algeria on the evening of the 20th, remained at Philippeville until 12 o'clock on the evening of the 21st, and arrived at Bona at 4 o'clock in the morning of the 22nd August.

A visit to Philippeville is a delightful introduction to Algeria. Though not one of the largest towns on the coast, it is very picturesquely situated, and the luxuriant vegetation adds to the charm of the natural formation of the ground. The streets and roads are lined with eucalyptus trees. Figs, grape-vines and oleanders grow in profusion, and what is known here as the common bramble or blackberry lines all the hedgerows and was laden with fruit. Vegetables of all kinds are grown freely by the aid of irrigation.

The town is surrounded by large orchards and market gardens, growing pears, haricots, tomatoes, artichokes and many more familiar vegetables.

There is evidence here as in other parts of the country of the terrible scourge of Phylloxera, which is everywhere in Algeria and Tunisia. Efforts are being made to introduce the culture of American vines, as they appear to be immune from this disease.

Here also one makes acquaintance with the barbary fig or cactus fruit, very beautiful to look at and not bad to taste when one knows how to eat it, but an unskilled attempt to consume this dainty results in very serious discomfort ; for the hand, lips and mouth are attacked by the small thorns on the skin of the fruit, which are very sharp, strong and short, and exceedingly difficult to remove from the skin and mucous membrane.

The proper method of dealing with this fruit is to cover the hands with a cloth when pulling it, then to rub it on the ground until the spines are all removed, when it can be peeled and eaten.

About eight miles from Philippeville is the old Roman fishing village of Soultra, where some of the members of the Expedition took to the water and enjoyed a swim.

Being desirous of proceeding to the objective without delay, arrangements were made to leave Bona on the day of our arrival. Before starting, however, a visit was made to the American Cruiser "Dixie," Captain Merryman, which was lying in the harbour, having brought the members of the American Expedition, who proceeded to Guelma, a station about half as far from the coast as Kalaa es Senam.

Mr Crookston had made the most complete and thoughtful

arrangements for the convenience and comfort of the Expedition ; and from the time of departure from until the return to Bona the transport and commissariat were carried out by his agents in the most perfect manner.

Leaving Bona by train at noon on the 22nd, after traversing a plain for about thirty miles, the train commenced an ascent of about 2,000ft., arriving at Morsott at 9 p.m.

A railway journey in Algeria is a novel and interesting experience to a stranger. The train is made up on the corridor system and is in three classes. The third class is practically entirely occupied by Arabs in their native dress. The second class is occupied partly by Arabs and the better class of commercial people of various nationalities.

The Arab is strangely out of place in a railway carriage. He does not know how to sit on a bench with his feet on the floor. He wishes to sit, as he does at home, on the ground or on a divan, and the seats are too narrow for this attitude. He is therefore silent and somewhat uncomfortable on the journey, except when the train stops at a station, when he is ready to get out and talk with his friends.

The sound of their conversation is not unfamiliar to a Scotsman, as their language is guttural and their voices are high pitched.

A few women were in the train. They are even more out of place than the men, for, traditionally, it is not respectable for them to be in any such place.

The scenery on the ascent is reminiscent of some parts of Switzerland. On the lower ranges of the mountains the vegetation is luxuriant ; but as the road rises the vegetation decreases, until at last nothing is left but a little scrub and rocks and sand. High up on the line the railroad crosses the main track between Tunis and Algiers, and this is occupied by Arab settlements of a temporary character. Very few houses are visible. The people live in large brown tents of their native cloth, the tent, oblong in shape, being supported by a central pole. The cloth reaches to within about 2 ft. of the ground, this space being filled up by dead scrub, branches of trees, stones, etc.

There is not much privacy about an Arab tent ; and, were it not for the advance guard of vicious dogs that give a noisy warning of the too near approach of a stranger, it would be easy to observe the domestic life of the occupants.

Morsott is the site of one of those Roman villas, which remain

after seventeen centuries to tell of the colonizing enterprise, the high ideals of domestic comfort, and the engineering and architectural skill of that wonderful people.

The only running water we saw away from the towns in Algeria was from the supply laid on by the Roman gentleman who built this house.

Starting from Morsott at 4 a.m. on the 23rd, a drive of 48 kilometres with a further ascent of about 1,000ft., during which we crossed the border into Tunisia, brought the Expedition at about noon on 23rd August to the site chosen for the observations.

The Eclipse occurred and was successfully observed on 30th August, and the Expedition left Kalaa es Senam on the return journey on the 3rd September, following the same route as on the outward journey with the exception of the call at Philippeville, and the addition of a short tour in the south of France while waiting the arrival of the P. & O. steamer.

The work of the Expedition was to take photographs of the eclipsed Sun, with a view primarily to the study of the Corona, which, when the sun is not under Eclipse, is invisible owing to the greater luminosity of the sun's disc.

The scientific records are at the present moment in the form of photographic plates, the interpretation of which involves a long and laborious expert study, and must remain for some time unpublished until Dr Becker and Mr Franklin-Adams are respectively in a position to present them to the public in proper form.

Dr Becker's apparatus consisted of a siderostat and two telescopes, and arrangements for exposing two series of photographic plates placed opposite the eyepieces of the telescopes so as to obtain images of the eclipsed sun. This apparatus was worked automatically by electricity. Twenty exposures, ten at each telescope, were made in $3\frac{1}{2}$ minutes during which time the sun was totally eclipsed. The shutters between the object glass and the siderostat, also operated automatically by electricity, were so arranged as to give the required number of exposures of different periods.

Mr Franklin-Adams' apparatus consisted of a siderostat and a telescope mounted with a dark slide at the eyepiece end, a whole-plate camera directed to the siderostat, and a smaller camera directed to the sun.

A smaller number of photographs of larger size were taken by

this group of apparatus which was operated in the usual way : changing plates and exposing by hand. A small telescope was provided that direct observation of the progress of the Eclipse might be made for the guidance of the operators.

The Expedition was also provided with chronometers and theodolite for exact determination of the latitude and longitude of the station of observation.

The transport of the plant was accomplished without damage, although the latter part of the journey was rather a rough trip for delicate instruments. The journey from Morsott to Kalaa by carts was one which, if it had been foreseen, would not have been so lightly undertaken.

Leaving the railway for the road, if one may use the term to describe what often bears a very remote resemblance to a road, one becomes more closely interested in the animals that accomplish the transport.

In Algeria the variety of beasts of burden is considerable. The ass, mule, camel, ox, horse, and one might almost add the woman, all take their share. The ass is the most universally used, and is capable of carrying surprising loads, never so big or so heavy as to relieve him of the responsibility of carrying his master on the top.

The ox is somewhat less in evidence on the roads than the other animals ; and in the country we passed through the camel was not very extensively used. It seemed to be rather a breeding and feeding ground for the camel than a district where he is used for ordinary work.

It has been said that cows in grass parks must attend closely to the business of nourishing themselves. A camel must, indeed, have a busy time if he is to charge his huge cavity in a working day. A browsing camel is a quaint creature. He seems to sweep into his great mouth all the greenstuff in the neighbourhood. His long tongue, his projecting, scooplke lower jaw, and great length of neck, give him all possible advantage ; but at the best it must be harder work to feed himself than even to carry his load. A camel has an odd way of looking at one. Most animals droop the head to inspect an intruder ; the camel lifts his high, and looks at you over the sides of his face, so that you see his chin above the level of his eyes. A herd of camels is a weird spectacle, like a flight of wingless geese or swans, the necks outstretched and motionless, or very slowly swinging from side to

side, the legs not inconspicuous, the barrel or bulk of the body very much more so, the heads so lightly carried that they seem to float in the air. The sound is not of treading, but as of breathing or sighing; the progress apparently slow, but really fast, stately, light motion, with a sense of weariness. They are a queer looking crowd.

The horse is much less important to the Arabs in their peaceful state than when they are following their warlike occupations. Every well-to-do Arab has a horse. While he is young and beautiful he is petted and much taken care of. When he is old—there is no S.P.C.A. in Algeria. It is only fair to say, however, that Arabs are much less actively cruel to their horses than Spaniards, Italians, or Russians.

The mule is really a more useful animal than the horse, and seem to be preferred for the heavier work. A number of them dragged the carts with our apparatus across watercourses, over rocks, and up and down slopes which would paralyse any other animal than a mule.

He is also a good animal to ride upon, and is reputed to be safer than a horse. He assumes personal responsibility for the job he undertakes in a way that inspires perfect confidence in the heart of the rider.

The phrase, "stupid as a mule," arises from a total misapprehension of the mule's character. He has a perfect comprehension of the business of keeping on his feet and doing his work; but he has a policy of his own which is not always the policy of his rider, and their mutual relations are apt to become strained.

When a mule is put in a position of responsibility and sets out on his journey, the ratepayer on his back becomes a mere incidental portion of the furniture of official muledom; and, if necessary to the completion of his policy, the mule will calmly pursue his journey under a fig-tree or an arch, or alongside a wall, and wipe the rider off his back, with no disturbance to the even tenor of his way.

It is this quality (so valuable to a government), of self-respecting stability to which we owed the safe arrival of our precious freight and ourselves.

After the arrival of the mule carts, no time was lost in proceeding to erect the apparatus.

It was necessary first of all to determine the latitude for the adjustment in position of the siderostats.

The siderostat is an apparatus consisting of a mirror free to rotate about an axis parallel to its plane, and parallel also to the earth's axis. The mirror being rotated by a clock at half the rate of the earth's rotation and forming by reflection an image of the sun, the image remains stationary, and, a stationary telescope being focussed upon the image, a photographic plate can be exposed in front of the latter for any desired time.

It was considered that six complete days would be ample time for the establishment of the temporary observatory with the necessary shelter for the observers from the sun's heat during the time of setting up and adjusting the instruments.

Any work carried on in the sunlight had to be gone about in a very leisurely manner—one soon learned why. The stranger enjoys the brilliant sunshine. His head is sheltered by a pith hat, he is lightly clothed, and he feels the biting scorch of the sun's heat as a pleasant stimulant. By-and-bye he finds that he is becoming breathless, that his heart is increasing its normal pulse until it plays like a kettle-drumstick against his ribs. His head grows light and his feet heavy, until he is fain to sit down in what shade he can crawl to and wait for calmer moments. When he starts again he imitates as nearly as he can the stately, leisurely, low-lifted stride of the Arab, and he reserves his energetic movement for cooler climates.

After the first effects of fatigue and exposure to the heat had been overcome, good progress was made with the erection of the instruments; and the clear atmosphere and entire absence of clouds raised the spirits of the Expedition to good working pitch. This was not to last long.

On the day after arrival the first tent was erected and the apparatus-cases opened, and we were proceeding to put things together, when, at about 11 o'clock in the forenoon, after we had been at work for six hours, there was "a change in the weather" which developed while we were at breakfast to such an extent that it was deemed prudent to strike the bell-tent, which was never re-erected, and to reduce the size of the shelter over the large instruments to the smallest possible dimensions. This storm was the first of a series of three cyclones with wind 40 to 60 miles an hour, hail, rain, and thunder and lightning, and one sirocco with dust in similar doses.

The sirocco occurred on the 29th, the day before the Eclipse. The storms usually lasted from just before noon, until after

sunset, when the sky cleared and the nights were fine. The intervals of calm were just about sufficient to enable us to replace the work which we had dismantled on the approach of the storm, and from day to day the siderostat mirror became more and more obscured by rain, dust and dead insects ; the delicate clock mechanism more and more distressingly dirty, and the observers more and more disheartened.

Assured on the one hand that there never was in the memory of man such weather in August, and on the other by a more brutally frank witness—"Il est toujours comme ça ici," we came to the sorrowful conclusion that whatever might be done by other expeditions the Glasgow one was engaged in a hopeless business.

We had the satisfaction of observing under the most advantageous circumstances the advance and development of cyclonic storms, and the display of atmospheric electricity was well worth all the trouble ; but work of any kind outside was utterly impossible, and one member of the Expedition whose humour was not quenched, but only rendered cynical by the lash of the elements said :—"This is the class of territory which the generosity of our rulers leaves to the colonizing enterprise of our competitors." On the fateful morning of the 30th, at 4 a.m., the sky was clear and the Expedition was at work as usual.

The mirrors were cleaned, the temporary lashings removed from the telescope, and by twelve o'clock, local time, every one was at his post, ready. A rough rehearsal of the photographic operations was gone through during the morning, and at fifty minutes, eleven seconds—local time ; sixteen minutes, forty seconds—Greenwich time, the first contact of the Eclipse occurred. The observer at the telescope called out the observation of first contact ; recorded the time of it, and then the time of the complete totality about $1\frac{1}{4}$ hours after first contact ; called out the time at intervals during totality for the guidance of the operators, and finally recorded the time of last contact about $1\frac{1}{4}$ hours later. It will be seen that during the $3\frac{1}{2}$ minutes of totality there was plenty of occupation for everybody, and small opportunity for casual observation outside the direct duty of the moment.

It is well known that non-combatants see most of the fight. If you wish to see an eclipse of the sun, do not take an active part in photographing it. The time of totality passes like a flash.

The Corona can be well seen without a telescope and is a most

striking object. A picture gives some vague idea of what it is like, and an attempt will be made to show an electric model of it.

The $2\frac{1}{2}$ hours of partial eclipse were available, of course, for general observation, but this part of the phenomenon was probably as well seen at Glasgow as at Kalaa. One thing, however, may be mentioned. As the decrescent sun became thinner and thinner until its horns were mere threads of light round the dark edge of the moon, there came out in startling prominence the great volcanic peaks and craters of the moon, the sunlight breaking through the gaps, and the thread of light being broken up into spots by the interrupting peaks.

So much for what may be termed the objective aspects of the Expedition.

An account of some of the subjective aspects has perhaps quite as much interest for those who are not experts in the most abstruse of the sciences.

Travel is always exciting. The more exciting when its object is definite, most exciting when it has for object the experience of events differing from and transcending the common events of life. If it be exciting to travel, to study antiquities, to see continents and oceans and peoples, and to hunt wild animals, it is reasonable to expect a rare excitement if the object of the hunt is out in the blue, and is no less than the central and most conspicuous and important object within our ken.

A new sense of life comes to the southward sailor as the ship sails out into the open ; this impression is deepened when one goes from the deck of a ship to the hurricane deck of the world ; and on the mountain, tentless, naked to the sky, feels the very rock and spin of the earth itself as it floats and swings in the coastless ocean where day and night are one, and time and distance fall away, and the chartless stars are voyaging—*to what port?* Such emotional experiences are rare and all too volatile, but the environment which brings them is good to breathe and walk in.

The travellers on this expedition, environed as they were by the finer, subtler skyey influences, and occupied also by many details of their duty, were not always wrapt in transcendentals, or mathematics, or overwhelmed by the wrath of the elements.

The great heat necessitated repose during much of what is our ordinary waking day. The clear cool nights held us in their thrall ; there was no time for going to bed, and the morning

call at 4 a.m. was often anticipated by a stroll in sleeping garb in the yellow dawn, or earlier.

These nights were a delightful preliminary to the observation of the Eclipse, and also a most interesting occasion of contact with a master teacher of astronomy. None more patient with ignorance, none more lucid in explanation, he brought vividly before the mind the conception of the celestial sphere, in which the globe and all that inhabit it shrink to a point in space; teacher and pupil alike delighting in the experience of seeing in large what in Scotland is usually represented by the lame and impotent convention of diagrams and figures.

It is well worth while to go south into the clear sky to see the Milky Way. Here it is rarely to be seen at all; there it is a conspicuous and splendid spectacle. To the naked eye it appears like a luminous fleecy cloud of phosphorescent smoke with whirls and eddies and glowing points of light. Seen through a field glass or low power telescope the great star clusters and Nebulæ are separated out and are less pictorially beautiful and more interesting to the astronomer.

The Ecliptic (the region of the heavens occupied by the sun and planets in their apparent motion in the celestial sphere) was, during the time of the Expedition, mapped out by the positions of three major planets which were visible every night.

Shortly after sundown Mercury was visible near the head of the Scorpion; A few hours after Mercury had set, Jupiter, the moon, and Venus rose from the eastern horizon, and it was easy to forecast the position of the moon in the neighbourhood of the sun by observing her gradual approach to the ecliptic.

Shrouded as we are for the greater part of the year in a not altogether disadvantageous veil of cloud and mist through which the long-slanting rays penetrate in a dim uncertain way, we find it difficult to import into the very name of the sun the tone of intimate familiarity in which the inhabitant of more favoured climes speaks of "le soleil." To him the sun is the companion of his every-day life, not to be faced indeed with undue familiarity, but on the whole beneficent and beautiful. The mid-day sleep pushes the waking hours back to the rising of the sun, when the sky brightens as quickly as it fades in the evening, and the sun is separated from the stars by but a short twilight, so that there is no time when the sky appears empty.

Everywhere we found a lively interest in the expected Eclipse.

The most unlikely people knew that it was coming, and the day and hour of its happening ; and we heard no whisper of superstitious fear or wonder. During the Eclipse, when the pigeons came home to their cotes and the domestic fowls went to roost, the men stopped their work and gazed, so that looking from the height over the plain all the people were facing one way, the backs of their heads turned towards us and all their figures motionless.

To us who had come far and through various tribulations to seize a record of the happening during three-and half minutes of total eclipse, the time was full of tense anxiety so that the impression of the great event itself is somewhat vague and indefinite, but there remains a sense of overwhelming strangeness. The lamps which we had placed on the outside to enable us to see the chronometers proved to be unnecessary. The darkness was never total ; at the most about equal to an autumn dawn in Glasgow an hour before sunrise, one star only having been specifically observed near to the sun.

The sun itself was not dark. The reminiscence of it has no shadow in it, but a fierce, weird ring of brilliant white light surrounding a disc of violet, giving the impression not of shadow, but of a quivering, trembling mass of deep colour like the pupil of a living eye. Beyond the white ring and all round it for a distance equal to about the diameter of the central violet portion, a crown of livid light, like the brush discharge from an electric machine or the glow in a vacuum tube, indefinite in outline with streamers radiating more in some directions than others ; an impression of breathless suspense, a fluttering puff of cool wind, and then a flash of intenser light, the first appearance of the sun's limb, dazzlingly bright by contrast and quickly increasing, defining into a crescent, and all was over. The increasing crescent seemed a tame and ordinary thing, and was left almost unnoticed while the photographs were being developed, and the courier waited, mounted ready for a twelve mile gallop to the military station in the plain whence a telegram was to be sent, announcing the successful completion of the observation.

We have called Kalaa es Senam "The hurricane deck of the world." Its name signifies "The Fortress of the Teeth." There, on the naked rock, 4000 feet above the sea level, are men making their homes, men to whom the plain and the crowd are known casually, or from afar, whose instinct is to climb and to get out of the common herd on the low ground.

This instinct may be quite wrongly idealised. It is often associated with the predatory instinct, and it may be associated with the characteristics of the Puffin as probably as with those of the Eagle. Those who make their home on the top of a naked rock practise the simple life not as religious enthusiasts, economic faddists, or morbid abnormal cranks, but in the natural ordinary consequence of their heredity and environment.

Those folks produce upon people like us the strange sensation that we look upon members of our species with like wants and feelings and passions to our own, and who yet are of the fauna of their country. Their superior position in the scale of animal life enables them to exclude other animals in a state of nature, and to select those which are in no sense competitors, but only slaves or quarry to the masters of the situation. Their geographical position places them in an isolation which, if from our point of view is not splendid but squalid, is at least complete. The simplicity and singleness of their life is not invaded even by a blade of herbage. The only live wild things not human in their immediate neighbourhood are the grasshopper, and the snail which lives on the naked rock like the dog-whelk in the sea.

They descend to procure their food, cultivating, with much toil on the sheltered lower levels, a few handfuls of grain which they beat out on threshing floors by the feet of their cattle, and carry up to the height to be stored in holes and caves of the rock.

The Kalaa has been the home of such people for uncounted ages. To-day on the top are the relics of occupation in the early centuries of the Christian era, and the ruins of the houses of the murdered predecessors of the few families who live there now. The children enjoy the privilege of free education in a well-ventilated school, a building not made with hands, whose roof is the sky. The teacher is Nature, the good old nurse, and her code of punishment includes wounds and death, and her rewards are bare food, drink, and some little clothing and shelter.

In the early dawn, while the rock is still enveloped in mist and the plain is hidden from view, the men and the elder boys and girls silently collect the sheep, goats, and cattle from their shelter, and descend about 500 feet by the winding staircase, partly tunnelled through the rock and partly built or hewn on its face, and emerge from the old oak iron-studded door which is hung on the portal at the foot. The staircase is worn by the feet of many generations

of men and animals, the hoofs making a set of tracks of their own and cutting the stone into holes.

Emerging from the portal they are still high above the plain, but in the shadow of the rock there is some herbage and a few flowers, gold and purple thistles, small shrubs like junipers, various yellow composite flowers, dandelions, dianthus, and a few succulent plants. The animals wend their way slowly among the fallen rocks and pick up some scanty livelihood. None of them are fat, some of them are emaciated.

The exit from the rock staircase faces the east, and as the herds descend the mist opens, and the plain looms out purple, orange, and yellow. The men go off on visits of business or pleasure to the encampments or settlements of the plain. The young folks climb to the tops of great stones where they lie watching what motion there is to see until the heat of noon, when they and their animals seek the shelter of the stones and lie asleep or quiescent until the sun permits them again to move on in search of food.

On the top of the rock the women and children remain secluded; the old women carding and spinning wool, the young ones weaving it into the burnouse, or grinding the grain in the stone quern, coming out to the edge of the rock to call like birds to the homecomers in the evening.

That is the story of the life of the Arabs of the Kalaa. When we think of the rock and its inhabitants, we see it clear in the starlight, smoking with the mist of early dawn, standing out like a fire in the heat of the day, wreathed in the blackness of whirled clouds, hail, rain, and howling cyclone wind, illuminated and struck by lightning, half biotted out by the dust of the sirocco. And as we pass the oaken door and mount the staircase to this human eyrie we meet in the way a soft-voiced man who lifts his right hand, open, palm to the front, to the side of his bearded face, saluting, then kisses his hand, offers it to the stranger, and after shaking hands kisses it again. Far above, sits a woman like a bird on the rock. Her habit is dark blue with crimson and orange about the neck and head. Her face and eyes are yellow, blue spots tatooed on her brow, the folds of her mouth, nostrils and eyes are upturned at the outer ends, and the look on her face is the inscrutable beyond going look of the Sphinx and the mummy picture; and as she sits, she spins always and lifts her skinny arm to the sky. The children peer over like wild things, and away in the dark among

the ruins, in sun and mist, in calm and storm, there sits on the ground cross-legged, the girl wife, the weaver with her naked babe in her lap—her only outlook on the world through the warp of the cloth between her and the doorway of her windowless chamber, passing the threads from right to left, from left to right, and packing them down with a little wooden pin, her clothing of bright colour and her bracelets, chains and earrings tinkling as she moves. That vision realises the dreams of many an old and new time poet, and suggests many thoughts.

I hardly dare turn the picture. This is no jest, no profanation of high images, though you will, having human spleens, laugh when you hear it. It is life itself, paradox, contradiction, anti-thesis astounding.

In the bowels of this naked rock, the hurricane deck, the roof of the world, this human eyrie, this sterile refuge removed afar from everything which complicates and disturbs the worldly life there is a Scotsman from Glasgow with electric drills, tearing out its entrails, grinding them to dust and sending them to the uttermost ends of the earth to fertilize the soil. This is to me the most striking of the impressional visions of Algeria and Tunisia. A visit to Algeria may be made from Glasgow by an energetic traveller in a fortnight, and he can meditate for five days of that time on the unchanging civilisation of the Arabs side by side with the development of European industry. He may see stone querns for grinding wheat sold in a shop next door to another where he can buy Swiss watches and American alarm clocks. He may see the changeless, restful East sitting down by the highway as the West goes by. Who shall say which holds the secret of happiness for the human life?

Saint Serf's Priory in Lochleven. By F. J. AMOURS, B.A.,
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[Read before the Historical and Philological Section on the
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THE small island called by Wyntoun "the Inch within Lochleven" played its part for eight centuries in the religious life of the east of Scotland; but that part was a modest one, and so its annals are scanty. Those records are either buried in legends or scattered through the archives of monastic houses, too few of which unfortunately have reached us. So many links are wanting that it is impossible to form a complete chain; however, it may not be without interest to gather together all the information available about the house over which the first Scottish Chronicler ruled for more than thirty years.

The first name connected with the island is that of Servanus, or Saint Servan, popularly shortened to Saint Serf. Servanus lived in a dark age, and the legends composed about him long afterwards have not cast much light on his real life. His history is to be extracted from the so-called lives of the Saint himself and from the life of Saint Kentigern. According to the longer legend,¹ in great part translated by Wyntoun,² Servanus was the son of the King of Canaan, in the land of Egypt, and of Alpia, the daughter of the King of Arabia. He was baptized and brought up by the Bishop of Alexandria. The Canaanites elected him their bishop. Twenty years after, directed by an angel, he went to Jerusalem, where he was bishop for seven years, then to Constantinople, and from there to Rome, where he was pope also for seven years. The same angel then sent him away again into foreign parts, and with a large company he crossed France and England, till he came to the Forth. Adamnan, who was then an abbot in Scotland, came and met him on Inchkeith, and gave him and his companions all the land of Fife to live and work in, "from the hill of the British to the Ochils." Brude, son of Dargart

¹ Skene's *Chronicles*, p. 412.

² *Chronicle*, V., ll. 5119-5334.

king of the country, not having been consulted, objected ; but soon after, he was cured of dropsy by the Saint, who, as a reward, was allowed to settle in Culross. Afterwards, Adamnan gave him the island of Lochleven, where he lived for seven years, founding a monastery and gaining the souls of many. There is no mention here of Kentigern, who, in his own legends, is said to have been brought up and educated by Servanus, then in his old age, who in his youth had been made a bishop by Palladius.

So, if we believe the legends, Saint Servan was a contemporary of Palladius, of Kentigern, and of Adamnan. Now there are historical dates connected with those three. Palladius was sent to Scotia, that is, to Ireland, in 430. The year is given by a contemporary chronicler, Prosper of Aquitaine. Kentigern died in 612 at the latest, and Adamnan was abbot of Iona from 679 to 704. Evidently, Saint Servan cannot have been the contemporary of any two of them. The legend contained in the lessons of the Aberdeen Breviary for Saint Servan's day (July 1st), apparently a late compilation, partly eludes the difficulty by stating that there were two saints of that name, one the fellow-bishop of Palladius, the other living at the time of Adamnan.

If we turn from the legends to the chronicles, we tread on ground that is slightly firmer, but still full of pitfalls. The author of the *Scalacronica* has inserted in his book a version of those thirteenth century chronicles of the Picts and Scots, which consist mainly in lists of their respective kings. In the list of the Pictish kings is this entry : "Brude, son of Pergard, reigned 31 years. In his time Saint Servan came to Fife."¹ This Brude died about 706.

This was a stirring period in the history of the church. The monks from the West had come into touch with those from the South, and were getting worsted. The Columban Church, that had been established in Northumbria in 635, had been obliged to retire before the impetuous Wilfrid in 664. The southern Scots of Ireland had conformed to Rome as early as 634, followed by those of the North in 692 ; Adamnan himself had been converted to Roman use in 688, during his second journey to Northumbria, although he could not persuade his own monks to share his views. The majority of the monks of Iona did not adopt the Roman rites till 716. The Columban monasteries

¹ Skene's *Chronicles*, p. 201.

settled among the Picts resisted longest of all, and were expelled in 717 by Nectan, brother and successor of Brude.

Here Saint Boniface comes on the scene, and his Scottish legend¹ runs on the same lines as that of Saint Servan. He also is from the East, he also becomes a pope, he also is sent to convert the Picts, and he baptizes Nectan at Restennet. One point to note is that one of the seven bishops who accompany him is called Servandus. Another is that if we turn to an older and more trustworthy Irish document, we learn that his real name was Cuiritan or Quiritinus, and that he was an Irishman. The mother of Servanus, according to another writing of the ninth century, was the daughter of a king of the Cruithne. So everything tends to prove that Boniface and Servan formed part of the new clergy, who came to work among the Picts about the time when the Columbites lost favour with Nectan.

The meetings of Saint Servan with Adamnan need not be accepted literally; yet Adamnan was twice in Northumbria, where he became converted to the new ideas, and he may also have been in Fife, visiting the Pictish monasteries connected with Iona, and trying to bring them over to the Roman ways, that were gaining ground everywhere.

The connexion of Servanus with Lochleven does not rest on the legends alone, but also on a document that deserves special attention. One of the most valuable pieces preserved in the Register of the Priory of Saint Andrews is a short summary of the old donations granted by the kings of Scotland to the church of Saint Servan in the Isle of Lochleven. It was translated in the fourteenth century from an old volume written in the Scottish language "in order that no superfluous questions, and no noisy wranglings should needlessly reach the ears of kings, princes and bishops." The opening statement reads thus: "Brude, filius Dergard, qui ultimus regum Pictorum secundum antiquas traditiones fuisse recolitur, contulit insulam Lochleuine Deo omnipotenti et Sancto Servano et Keledeis heremitis ibidem commorantibus et Deo servientibus et servituris in illa insula."² This simple looking sentence has been explained in different ways. The expression 'ultimus rex Pictorum' has been understood to refer to a Brude, king of the Picts immediately before Kenneth Macalpin, who put an end to the Pictish kingdom in

¹ Skene's *Chronicles*, p. 421.
VOL. XXXVII

² Reg. Prior. S. Andree, p. 113.
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840, thus shifting the donation of Lochleven from the beginning of the eighth century to the middle of the ninth. That is the opinion of Dr Reeves, adopted by Haddan and Stubbs. However, there is no Brude son of Dergard at that time.¹ In two of the lists the last king before Kenneth is Brede, son of Feredach, who reigned one year, or one month; in the other lists there is a Brude, son of Fodel, or of Fochel, who is credited with a reign of two years; but he is the second last king. Everything is full of confusion at that time, when the Picts, divided among themselves, and with two sets of kings, were also resisting the conquering Scots; and the two Brudes, if they ever reigned, had something else to do than grant land to the monks. Skene gets over the difficulty by saying that the writer is wrong in using the word 'ultimus.' Another explanation is so plausible and so obvious that one cannot help wondering why it has not been suggested before. The Latin statement simply means that Brude was the last king of the Picts according to the old traditions, that is to say, before his brother Nectan had abandoned them. There must have been in the old Celtic records of the monastery of Lochleven some reference to the changes that took place in Saint Servan's time, which the translator did not explain fully in his summary.

Another part of the same sentence has caused misunderstandings. Brude is said to have given the island to God Almighty, to Saint Servan, and to the Keledei dwelling there. We need not infer that Servanus brought the Keledei with him. The translator simply uses the conventional phrase of a later age, when gifts to monasteries and churches were granted first to God, then to the patron saint. The Keledei do not make their appearance in Scotland under that name till the time of Kenneth Macalpin: records of all kinds, however, are so scanty at that period, that it may be assumed that they began to spread at the beginning of the ninth century.

The Keledei, a Celtic word meaning 'socii Dei,' associates of God, or according to others 'servi Dei,' servants of God, were

¹ It should be noted here that Brude and his brother Nectan are called sons of Dergard only in the Scalacronica, in Gray's Chronicle, in the Legend of Servanus and in Wyntoun. Four other chronicles call them sons of Derelei or Decili. The spelling of proper names varies greatly in those old lists, and the difference is immaterial here, as the name of the father is not recorded anywhere else, and besides, the names of the two brothers occur in the same place in all the lists.

originally monks that forsook monasteries to lead a more ascetic life under stricter rules, either by themselves as hermits, or in small bodies, dwelling in separate abodes. Those of Lochleven are the only ones called hermits, which points to an early period, so that the successors of Saint Servan and of his fellow-workers were probably the first to be known by the name of Keledei.

We see from the next sentence in the same document that in the middle of the tenth century they were still occupying the island, and evidently not in a flourishing or safe condition; for their abbot Ronan, a man of wonderful sanctity, gave the place of their cell to the bishop of Saint Andrews in return for food and clothing. The bishop was Fothad, expelled from his see in 954, which supplies an approximate date. As he was a bishop of the Celtic church, elected by the Keledei of St. Andrews, the hermits of Lochleven were simply connecting themselves with a stronger establishment of their own order.

A century later, Macbeth (1040-1057), son of Finlach, and Gruoch, daughter of Bode, king and queen of the Scots, gave Kirkness to God Almighty and the Keledei of Lochleven, in return for their prayers. Macbeth also gave "to God and Saint Servan of Lochleven and to the hermits serving God there"¹ Bolgyn, the land of the son of Torfin. Kirkness is close to the eastern part of the Loch, and Bolgyn (now Bogie) in the parish of Abbotshall. These two grants were destined to be the source of great trouble in the days of Wyntoun.

About the same time, Malduin, bishop of St. Andrews (1028-1055), conferred the church of Markinch with all its lands "to God, Saint Servan and the Keledei,"² and his successor, Tuadal (1055-1059) gifted them with the church of Scoonie.³ Fothad the second, the next bishop and the last one of the Celtic church, who celebrated the marriage of Malcolm III. with Margaret, granted the church of Hurkenedorath (Auchterderran?) to the Keledei of Lochleven living there devoutly and honourably in a school of virtues.⁴ The translator of the old Celtic book adds that the prestations and dues paid of old by the aforesaid churches were thirty loaves, thirty cheeses, eight measures of barley and other payments expressed in Celtic terms, which he left untranslated, and which are not understood now.

¹ *Reg. Prior. S. Andree*, p. 114.

² *ibid.*, p. 114.

³ *ibid.*, p. 116.

⁴ *ibid.*, p. 117.

To these endowments Malcolm Canmore and his wife added the "villa" of Ballecristin, now Balchristie, in the parish of Newburn.¹ We are informed in the same document, but not in very clear terms, that all the successors of Malcolm granted every liberty to the "villa" of Kirkness and Portmoak, and to all "villas" that the Keledei possessed or might possess afterwards.

One last gift has to be recorded, and it belongs to the same period. Ethelred, son of Malcolm, abbot of Dunkeld and earl of Fife, granted Admore (now Auchmoor, near Kirkness) to Saint Servan and the Keledei "with every liberty and free from every exaction or demand from anybody in the world, bishop, king or earl." As this possession had been given to him by his parents while he was a youth, he offered it with all the greater affection and love. The grant was confirmed by his two brothers, David and Alexander, in the presence of many distinguished persons and all the community then serving God in Abernethy. All the priests, clerks and laymen, invoked the malediction of God and of all the Saints on him that would disturb, revoke or diminish the alms of Admore; and all the people answered: "Let it be so. Amen."²

"That burning furnace of every iniquity, Sir Robert of Burgoine (Burgonensis) annoyed and harassed wickedly and unlawfully those religious men with violence and wrongdoings, wishing in the eagerness of his rapacity and of his unbridled tyranny to take away from them the fourth part of Kirkness."³ Thus begins an indignant report of the trial of a complaint by the monks of St. Serf's Island to king David about 1130. The king, moved with pity, sent his messengers through the province of Fife, and Fotherith, and convoked a large multitude of men, namely, Constantine, earl of Fife, "with his satraps and satellites, and the army of Fife," Macbeth, Thane of Falkland, the heads and leaders of the bishop's army, and others. The decision was entrusted to three men versed in the law, Constantine, the great judge of Scotland, Dufgal, son of Mocche, an upright and venerable old man, and Meldoinneth, son of Machedath, a good and discreet judge. The monks gained their case. The names of the clerks that swore to the boundaries are Duftah, priest and abbot; Sarran, son of Sodelne;

¹ *Reg. Prior. S. Andree*, p. 115.

² *ibid.*, p. 115. ³ *ibid.* p. 117.

Eugenius, monk; Donald, grandson of Leod; Morrehat, an Irishman of venerable old age; and Cathan, an old man. They probably belonged to Lochleven.

The dwellers in St. Serf's had now reached the high-water mark of their prosperity, such as it was. The Celtic church, the chief weakness of which from the beginning had been its want of organization, was now dying of decay. After the death of Fothad, Saint Andrews had remained without a bishop for fifteen years, till Turgot, prior of Durham, was elected in 1108; and in those days, in the words of a chronicler, the whole right of the Keledei throughout the kingdom of Scotia passed into the bishopric of Saint Andrews. In 1115 the first Augustinian canons were brought from England to Scone, by Alexander, the same prince who had lately confirmed the last gift to the Lochleven monks, and they soon spread over the East of Scotland. They had originated in France as far back as the eighth century, and at the beginning they were anchorites living under rules of their own, very similar to those of the Keledei of Scotland. In fact, they might be called the Keledei of the South; but in 747, Chrodegang, bishop of Metz, took them on hand, codified their rules, and brought them into the regular service of the church. Their numbers increased rapidly in France and in England, and the similarity of their ways of life, half regular, half secular, with those of their congeners in the Celtic church made the absorption or displacement of the latter a matter comparatively easy.

In 1144, Bishop Robert, who had been the first prior of the Augustines at Scone, founded a priory of canons regular in Saint Andrews, and within a few years King David granted to the new house the Island of Lochleven in order that a canonical order might be established there.¹ An important clause was added: the Keledei found there might remain with the new canons and under them if they were willing to live regularly; but if any one resisted, he was to be ejected from the island. In connexion with this change there is also a charter of Bishop Robert granting the "Abbey" of Lochleven to the prior of Saint Andrews, that he may establish canons regular in it.² That charter contains a full list of all the possessions of the Keledei: Findachin (not heard of

¹ *Reg. Prior. S. Andree*, p. 188.

² *ibid.*, p. 43.

before) with one mill, Portmoak with mills at the bridge; Kirkness, half the "villa" of Urechehem (?), the church "villa" of Scoonie, twenty "meli" of cheese and one pig from Markinch; twenty "meli" of cheese, four "meli" of malt and one pig from Auchmore; twenty "meli" of barley from Balcristie; twenty "meli" of cheese and a pig from Bolgie, sundry tithes, and all the church vestments that belonged to the "Chelede"; and lastly, all their books, the list of which is given in full. Their library contained about a score of volumes, partly church-books, partly Scriptural books and commentaries. Two items deserve to be referred to: a volume of Sentences by the Abbot of Clairvaux proves that the last members of an antiquated establishment were in touch with modern learning, for Saint Bernard was living then; another, called obscurely "Origine," may be meant for some work of Origen, or perhaps, as suggested by Dr Reeves, for some tract "de Origine Mundi." Now, the greater part of Book I. of Wyntoun's Chronicle is literally translated from the "Origo Mundi" of Honorius of Autun, who died about 1140; so we may fondly cherish the thought that the later prior used the very volume that had been left by his predecessors. There is no trace of protest or struggle on the part of the dispossessed monks; so it is probable that they fell in with the new ways, and were satisfied to become canons of Saint Servan's, a cell of the new and well-endowed priory of the chief Scottish see.

The new state of matters lasted for a hundred years, so far as can be judged from the many Papal bulls granted to the Canons of Saint Andrews during that interval, confirming them in their own endowments and in those of the priory of Lochleven. Bishop Ernald (1160-1162) gave Portmoak, and Richard, his successor, Markinch to the priory of St. Andrews. The reason for those special charters is not known. There is also a charter of Malcolm, Earl of Fife, about Auchmore to the same effect (1245).¹

Matters seem to have been in a very bad state in the first half of the thirteenth century. Prior Thomas of Saint Andrews, after trying for eleven years to bring order and obedience among his canons, gave up the struggle, and retired, "as a humble disciple and novice," to the monastery of Cupar. His successor, Simon, in the words of Bower, "because the days were evil, and in order

¹ *Reg. Prior. S. Andree*, p. 44.

to escape from the treachery of the wicked and the slanders of the envious," resigned his post, preferring to rule over the secluded priory of Lochleven (1225). During the time of his successor in Saint Andrews, Henry of Norham, Bishop William Malvoisin founded a hospital at Scotlandwell for the poor and pilgrims who flocked to the island monastery; and, as it was done partly at the expense of Lochleven, Henry had to give his assent, which may help to explain Bower's statement that he left his house desolate and burdened with numberless debts when he resigned in 1236.

The canons of St. Servan's must have been in straitened circumstances about that period, for the next prior of Saint Andrews, John White (1236-1258) restored to them all their endowments by the will and counsel of Bishop Gamelin (1255-1271) "because it is right and equitable that the founders of the abbey should not be deprived of the prayers that are their due." In return the canons are to take charge of the cure of souls, and all the other burdens connected with the church of Portmoak; they are responsible for the spiritual to the bishop, and for the temporal to the prior of Saint Andrews, who reserves also to himself the right of appointing future priors.¹

The next prior we come across is Laurentius, only known as a witness to a charter of Bishop Gamelin, granted in Lochleven in 1268.² When all the benefices were taxed in 1275 for the relief of the Holy Land, Saint Serf's was assessed at £106 13s. 4d, and the priory of Saint Andrews at £3,333 6s. 8d.

The Lochleven canons did not remain long in possession of their own. An undated charter of c. 1290 by John of Haddington, prior of Saint Andrews, informs us that in the evident interest of his monastery, and with the unanimous consent of the chapter, they grant to Peter de Campania, clerk, the whole barony of Kirkness, etc., that is to say, all that belonged to Saint Serf's, for a sum of 53 marks out of the hundred pounds sterling settled on him by Bishop William Fraser as a yearly pension.³ Peter de Campania was the bishop's vicar, and so William Fraser mortgaged the endowments of the poor canons to reward his vicar's services. The engagement was to last till one year after his death.

Nothing is recorded during the Interregnum, nor during the

¹ *Reg. Prior. S. Andree*, p. 121.

² *Liber Cart. S. Crucis*, p. 66.

³ *Reg. Prior. St. Andree*, p. 176.

reigns of Robert I., David, and Robert II., except the presence of a prior of Lochleven at the parliament held in Cambuskenneth on 6th November, 1314.¹ In 1385, Robert of Montrose, prior of Saint Serf's, was elected prior of Saint Andrews. He was stabbed to death by one of his brethren, Thomas Platter, eight years afterwards. It is to be regretted that Bower, who devotes a whole chapter to his life, has not condescended to mention the name of his successor. Most probably it was Andrew of Wyntoun; as he appears on the scene about 1391, we may, without excessive guessing, infer that he succeeded Robert of Montrose in 1385.

Two sets of legal documents, containing the only facts known about the Chronicler, have been inserted at the beginning of the Saint Andrews Register. They are quite distinct in character from the other contents of the volume, and from the date of the writing, as well as from internal evidence, they were probably placed there at Wyntoun's own request. As these documents have never been translated, it may not be out of place to reproduce the substance of them here, omitting part of the legal phraseology.

The first set refers to a perambulation of the marches of Kirkness, and opens with a preliminary statement of the prior's case :

A stream coming down the hills of "Cabennartye" from a spring, called in the vulgar tongue "Gruoch's Well," flows through the land of Ballingry. East of this is a piece of land called Nevathy, through which the stream flows to "the Stanry Furde of Navathy." From that ford the road leading northwards to a heap of stones, called "Lykystyne," and on to Fyndawchty, is the boundary between the western part of Kirkness and the eastern part of Ballingry. The stream descending thence towards the eastern part of Kirkness to the march of Polnevere is called "the Wattyr of Louchty." First, at the western end of Kirkness, it divides the north of the church land of Ballingry from the south part of Kirkness; therefore it is consonant with all justice that, when the stream reaches the east of Kirkness, it should be the boundary dividing Kirkness from the lands lying opposite; and this cannot be denied or disputed, except by persons that are mad, demented, false, crafty, malicious, or wicked enemies of the cross of Christ!

This is followed by the official report of the perambulation of

¹ *Acts of Parliament*, I., p. 14.

the marches between the barony of Kirkness and the barony of Lochore, drawn up by the notary public, Thomas de Karnys. On the 6th of July, 1395, specially summoned witnesses assembled on a hill, or rock, at the "villa" of Balbechy, in the west corner of Kirkness. There were also present Robert Stewart, Earl of Fife and Menteith; Michael de Ramsay, lieutenant and sheriff of Fife, and a great multitude of prelates, nobles, and plebeians. The purpose of the meeting was to determine the boundaries between the lands of Kirkness belonging to the priory of the Island of Lochleven, and the lands of the barony of Kynnymond, belonging to John de Spital, so far as they extend over the marsh on the north side, and the lands on the south side, belonging to John de Bosville and Robert de Levingstone. The four proprietors were consenting parties, and three of them were present, Robert de Levingstone being represented by Thomas Sibald. An assize of good and trustworthy persons, freeholders and others, were chosen and sworn, namely:—John Heryng, lord of Glasclune, John Lasselis, Aye Johnson, Laurence de Balnavis, John Multrare, John Betone, Alexander Hagy, John son of Andrew, James de Demstartone, William de Meldrom, John de Balmacankow, Hugo de Ramsay, William de Drumduff, Andrew de Gatmilk, Thomas Madoure, Richard de Ballingry, Adam son of Andrew, and Andrew son of Duncan. Some of the jurymen having been objected to by the contending parties, the others came down from the hill with the whole company to the spot where the Lochty burn reaches the marsh between Kirkness and Capildray, a part of the barony of Lochore. After a great deal of inspection and mature deliberation, they proceeded from the west of the marsh to the east and returned. Then they gathered round the Earl by the side of the marsh, and Aye Johnson, their spokesman, delivered their unanimous verdict, which was that, as the course of the Lochty ceases to be distinguished where it enters the marsh, a straight line drawn from that point through the bog of Polnabar to a point where the estates of Kirkness and Kynnymond meet, shall be the true boundary between Kirkness and Lochore. Thereupon Andrew of Wyntoun and John de Bosvyle requested Thomas de Karnys to execute a public instrument as a perpetual record of the finding, which was done on the spot in presence of Walter, Bishop of Saint Andrews, and Alexander, Bishop of Caithness; of John Stewart of Invermeth, John de Glen, Thomas Sibald, Michael de Balfour, Henry of

Arnot, knights, of the venerable men Thomas Trayl, brother of the Bishop of Saint Andrews, William de Balmyle, chamberlain of the bishop north of the Water of Forth; Henry of Wedale, clerk to the earl and notary public, and of the noble men Duncan Cambell, son and heir of Colin Cambell, lord of Argyle; John Lyon, lord of Glammis; William Scot, lord of Balwery; Archibald de Coningham, Andrew de Ramsay de Redy, John de Stirling de Kildenry, Walter de Ramsay, son and heir of Andrew de Ramsay, Duncan de Ramsay de Balbugy, Richard Brown de Oterston, Alexander Gourlay de Kyncraig, William de Bosvyle, son of John de Bosvyle aforesaid, and many others.

One cannot help wondering whether Wyntoun had to entertain the company thus assembled on the priory lands; if he did, it must have taken many years to repay the cost out of the revenue from the marsh of Monlochty.

The second set of papers deals with a more complicated and more unsatisfactory case; it lasted more than twenty years, and we do know how it ended. William de Barclay, lord of Colerny, was the owner of the land of Bolgy, which was burdened at that time with an annual rent of eight bolls of meal and one pig. Sir William was several years in arrears by the end of 1394, when he was excommunicated by the bishop. The sentence was carried out on the following Palm Sunday by Fergus, vicar of the parish of Dunbolg, where Sir William was domiciled, with the customary ringing of bells, lighting and extinguishing of candles. The lord of Colerny remained obdurate, and even went the length of deforcing the "sergeant" sent by Wyntoun to seize and distrain on the land of Bolgy, taking him prisoner, and threatening with worse harm, "if help had not come speedily." Five years elapsed before he was, on account of his conduct, cited to appear before the bishop's court on the 16th of February, 1399-1400, to hear that he had incurred a second time the sentence of greater excommunication. The citation was delivered to him by the parish vicar in the presence of three witnesses, William de Fassynton, John Pringle, and Stephen of Dunmore; but he failed to appear. Matters seem to have remained in the same state for ten years longer, except that the prior requested and obtained, on the 16th of February, 1406-7, that all the documents should be transcribed in a public and authentic form for further use, as they had become so old and frail that they could not be exhibited when needed. This

"instrument of processes" was written by Thomas de Karnys and witnessed by John de Meldrum, rector of Ochtirdere; John de Stirling, vicar of Scoonie; Andrew Young, Thomas de Ford, of the same diocese, and John Glasinwricht, of the diocese of Moray, priests.

In 1411, Wyntoun brought before the court the Register of the Priory of Saint Andrews, the very volume still existing, and requested to have a transcript made of the passages that established his claims on the lands of Bolgy. Shortly afterwards his case was presented again before the official, in a libel dealing with the arrears of rent due at that date. The prior claims for twenty terms 10 chalders of meal, 20 pigs, and 40 shillings of expenses. William de Barclay did appear this time on the appointed day to answer the libel; but he only put forth some frivolous exceptions, and left the court. Then the official sent him letters, through the usual channel of the parish vicar, citing him to come and hear the interlocutor as to his exceptions. We know nothing further, except that in 1413, Wyntoun was busy getting another transcript of his titles.

We can now understand the spirited outburst with which the Chronicler concludes the story of Theodosius and Saint Ambrose:

"The dedis of this emperoure
 Sulde be, lordis, your meroure.
 Til bischope al time bowsum be,
 And prestis luf in cheryte;
 Pay at ye aw thaim blithly,
 Tak nathynge fra thaim wrangwisly.
 It is an wnhonest tuyl
 To se the qwik the ded dispoile
 Quhen he is wondyn in his schet;
 The lik it is, I tel the yhet,
 Or than til it is the nest,
 A gentil man to reiff a prest.
 Off prestis at yowre begynnynge,
 And al your time, at your endynge,
 And estyr that, yhe haf mystar ay;
 Tharfor withe reuerens gret sulde thai
 Be tretit and lede honestly,
 And forborn richt getumly."¹

After another long gap, we come upon the name of another prior of Lochleven, Walter Monypenny. We learn from the Register of Brechin that he was in Antwerp in 1488; there in the German "hospital," situated in the English quarter, he made an agreement with Gaspar Bonciani, a Florentine merchant residing

¹ Wyntoun's *Chronicle* (S. T. S.), V. 3931-3954.

there, to the effect that Bonciani would endeavour to obtain through Philip de Strozzi and Co., merchants in Florence and in the following of the Roman Court, the bulls of promotion of William Meldrum to the bishopric of Brechin. Bonciani received two hundred pounds "*grossorum monetæ Flandriæ*," which he was to use as far as they would go, and his commission was to be 8 per cent. William Meldrum became Bishop of Brechin in that year.

In 1538, James Stewart, the future Regent Moray, was, at the mature age of five, made prior *in commendam* of the monastery of Saint Andrews. This was a favourite way of James V. to provide for the upbringing of his illegitimate sons; but it must have been a heavy drain on the revenues of the two priories. We may now understand the purport of two charters of this period. In one dated 9th of October, 1544, Michael Donaldson, prior of St. Serf's, with the consent of the commendator, grants in fee-farm to Robert Douglas of Lochleven the lands and baronies of Kirkness, reserving to himself the manse, "*the pryouris waird*," the island, with the right of fishing, etc. The rent to be paid amounted to about sixty pounds. This disguised sale of the property tided matters over for a few years; but in 1562 the reserved portion was encroached on also. In that year, on account of the heavy sums of money spent in the erection of the manse and the laying out of a large garden, Prior John Wynrame, with the consent of James Stewart, granted, in fee-farm again, to Margaret Stewart, widow of Master John Ayton, the manse, the garden, the houses and plots of five cottars, the prior's ward, Saint Serf's island, and the fishing for an annual rent, amounting altogether to £3, 13s. 4d.

John Wynrame was the last prior of St. Serf's. He survived the old order of things for a good many years, and adapted himself to the new. He married the widow of John Ayton, Margaret Stewart, a daughter of Alexander Stewart, Bishop of Moray, which may explain the transaction of 1562, and became superintendent of Fife and Strathearn. In 1575, he was still residing at Kirkness.¹ By a royal charter of the 29th of July, 1580, "the benefice of the priory of the island within Lochleven, otherwise called Portmook,"² was granted to the College of Saint Leonard, the usufruct being reserved to John Wynrame.³ He died on the 28th of September, 1582, at the age of ninety.

¹ *Reg. Episc. Brech.* ii. 308.

² *Reg. Mag. Sig.* 1580, No. 1.

³ *ibid.*, 1586, No. 1159.

Elberfeld System of Poor Relief.

By the Rev. ANDREW MILLER, M.A.

[Read before the Society, 29th November, 1905.]

LET me begin by recapitulating the leading features of the system. Elberfeld is a city of 164,000 inhabitants. The whole city is divided into 560 sections, each in charge of an almoner who has from 2-4 families in receipt of relief under his care. The almoner is not only the medium for dispensing aid, but he is expected to furnish full particulars of the income of the family from all ascertainable sources, to put himself into communication with relatives who may be either morally or legally liable to contribute towards their support, to aid the workers to get employment and generally to act as guide, philosopher and friend. Fourteen sections constitute a circle (*bezirk*) presided over by a superintendent. The circle meets once a fortnight, and at this meeting the almoner is expected to give an account of each family under his charge, from personal visitation and enquiry, noting any improvement in their circumstances or the reverse. This secures the closest personal surveillance of each family in receipt of poor relief. The circle in the first instance decides the amount of the grant, but the superintendent has a right of appeal to the *Verwaltung* against an adverse decision of the meeting. The *Verwaltung* is the Administrative Board. It consists of eight members, four of whom are chosen from the Municipality and other four co-opted because of their expert knowledge. It is to be remembered that the Municipality is elected on a much narrower franchise than with us, so that the composition of the *Verwaltung* is practically several removes from that of a popularly elected body. The *Verwaltung* has the appointment of the whole body of Almoners and District Superintendents, and they try to secure men from the more well-to-do classes, for the double purpose of bringing the two classes of society into closer unity, and of getting the services of those who will be least under the influence of popular pressure. The *Verwaltung* meets also once a fortnight, takes up all disputed cases and attends to the

administration of hospitals, poorhouses, etc., and other business that may arise.

The money required for the relief of the poor is not directly raised. It would seem in Germany that all taxes Imperial and Local are raised conjointly, and that the city frames its budget and gets handed over to it the amount required for Municipal purposes. Surely this is an improvement on our intricate and wasteful method of collection and distribution ! The Verwaltung also takes charge of all monies destined for relief of the poor, such as Interest on Endowments, Reserve Fund of Savings Banks, Police Fines, Profits of Official newspapers, Money received from relations of paupers, Municipal Pawnshops, Minor Sources. No account is taken of Church or Private Charity. Miss Sutter tells us that this does not bulk so largely in Germany as with us. The Verwaltung also fixes the maximum standard of relief. This has been steadily rising. According to the Parliamentary Bluebook of 1888, it was as follows, as compared with the latest statistics.

	1888.	1904.
Head of a family,	3/- a week	3/-
Wife living with husband,	2/- „	2/6
Child of 14 and over (if a worker),	2/- „	3/-
„ „ „ (if at home),	2/- „	2/6
„ 10-14	1/8 „	2/-
„ 5-10	1/3 „	1/7
„ Infant	8d. „	1/-

There is a further provision for supplying milk to infants up to 3s. a week. The allowance it will be observed is tolerably liberal.

So much for out-door relief. There are the usual other forms of aid. There is an Hospital, but it is to be noted that the Poorhouse Hospital is the only free Hospital. For admission to the City Infirmary payment must be made. The Poorhouse is reserved for the respectable poor. The Workhouse is for the detention of Mr Motion's "ins and outs." It is under police supervision, and inmates are sent to it for a period of from six months to two years. There is also in some cities a voluntary Workhouse, where an out-of-work can earn his living, very much on the principle of our Labour Homes.

An account of the Elberfeld System, however, would not be complete without a word regarding the Farm Colonies. It is

plain, that before any such system could work, the worthless, the drunken, the vicious, the unemployable generally must be swept off the field, and that there must be a Labour test sufficiently stringent to secure that every capable worker is doing his or her best to earn a livelihood. This point is gained by the splendid system of Farm Colonies, of which there are thirty-two in number. The Farm Colony is buttressed by the Relief Station, the Labour Bureau and the rigid scrutiny to which the tramp is subjected. If a man resolves to tramp in search of work he first applies to the Labour Bureau where he is told in what part of the country work is most likely to be found. The Labour Bureau at Cologne, which we visited, is a very complete Institution, covering the whole of Westphalia or Industrial Germany. He provides himself with a Wanderschein or Tramp Ticket, which is his passport. At the end of half-a-day's journey he finds a Relief Station where he gets supper, bed and breakfast, for which he gives half-a-day's work, and then proceeds on his way, after having got his Tramp Ticket signed. If at the end of three months he has failed to find work, a paternal Government finds it for him by sending him to a Labour Colony, where he stays a shorter or a longer time, leaving either for a situation obtained for him or to try his luck on the road again. Wherever he goes he is never beyond the surveillance of the authorities and his life is simply an alternation of road, labour colony and prison. Miss Sutter claims that by this method the tramp population has been reduced from about 120,000 to 20,000.

Any one who studies the whole system must be struck with its completeness—in theory at least. It provides for every possible case and leaves no loop-hole of escape even for the most improvident or vicious. In this respect it is a characteristic emanation of Teutonic genius. The German mind is logical and thorough. When it tackles a problem, no matter at what point a beginning is made, it never rests till it has reduced it to system. Here the chaotic element which lies at the basis of our modern civilisation has been transformed to a kosmos, which fits into the larger kosmos of the State and becomes part of the Teutonic Welt-Anschanung, and thus the intellect is satisfied. The German theory of the State is Platonic. Law is at the back of everything. Law and the larger liberty are made co-incident. The German citizen is "forced to be free." It is to be noted that even the almoner is not exempt from this dominance of Law.

He is not elected from below. He is selected from above, and if he shows any disposition to refuse owing to pressure of private interests, he is reminded of those elementary truths which Professor Jones has been impressing upon us so admirably, that in a civilised community every human being is the slave of the State to which he owes everything but the mere potentiality of life. If you refuse to fulfil a civic duty laid upon you by the general will speaking through the mouth of constituted authority, then says the Teutonic genius, thinking aloud, clearly you have no civic rights. You lose your municipal franchise, your taxes will be increased by a fourth, you can never hold any office of honour and dignity in the city. So it stands recorded in the Statute-Book. Not that there is any necessity of enforcing these penalties. I believe they never have been enforced. But the German makes laws to round off his philosophic conceptions, not because he thinks that any one has the slightest intention of breaking them. All over Germany you will find notices stuck up forbidding you to do things, which we would imagine nobody but a lunatic would dream of doing.

Are the actual results as perfect as the theory itself? What of the cost of the system as compared with our own? I wish some financier would take the trouble to work this out. Miss Sutter claims that it only costs half as much as ours. This is not the result arrived at in the Parliamentary Bluebook of 1888, where it figures out at much the same. The difficulty of comparison lies in this—that the revenue devoted to poor relief in Germany and in Scotland or England do not overlap. The sources of revenue are different and the expenditure is also different. Only half the amount expended by the Verwaltung is derived from taxation, while some things are included in their expenditure which are financed by us from private charity. The difficulty of an accurate comparison, however, is not insuperable, and it is worth while going into it.

As to the benefits conferred there can be no doubt. It has not suppressed begging, which goes on in Germany as with us. "Hawking and begging not allowed," was a notice we saw on some of the model dwellings in Dusseldorf, and when we asked our guide as to whether this notice was as supererogatory as some others we had seen, he simply smiled and said, "Ah! they do it all the same." You may drive human nature out with a pitchfork, but some where or other it will be sure to return. But it

has enormously minimised it. In Germany you are not importuned by beggars as you are here, and all signs of mendicancy and squalor are swept from the streets. The poor are altogether better cared for. Standing in the bureau of the Verwaltung and watching the people come and go, one is struck with the fact that they seem altogether a superior class to our paupers. They are better clad, cleaner, better fed and better mannered than the recipients of our State Relief. The system works well in Germany. Such was the universal testimony, and it was borne out by everything that fell within our observation.

But if we apply our own canons of criticism to the system and test it by those principles that have guided our administration of Poor Relief for the last seventy years, we will find that in many points it entirely subverts them. Take, *e.g.*, the voluntary workshops or farm colonies. It is a first principle of the orthodox economist that the State or Municipality cannot provide work for the unemployed without creating evils incomparably greater than those it would cure. The classic instance of the cataclysm in which such a policy would result is the Ateliers Nationaux of Paris in the year 1848. But this is just what Germany is trying to do, and to some extent actually does. It is true that the farm colonies are for the most part financed by private contributions, but they are subsidised and utilised by the Government. In Germany there is a system of State subsidy for all social experiments, corresponding, to our endowment of research. Bethel and Kaisersworth both receive a Government grant. The individual and the State are intertwined in the Fatherland in a manner foreign to our methods of thinking. There can be little doubt that if the farm colonies vindicate their utility they will become State Institutions. But the point is that the principle we hold sacred is not admitted in Germany as a principle, and that the Germans are hampered by no economic prejudices in endeavouring to solve the problem of work for the unemployed.

I ought to say in passing that the inferences drawn from the Paris experiences of 1848 seem to me much overstrained. You cannot fairly compare what was done in a year of revolution when the whole machinery of industry was dislocated by men ignorant of economic principles with what might be done in a period of political calm, the industrial situation normal, by men thoroughly versed in the economic rocks ahead. The conditions of the experiment are so different as to lead us to anticipate different

results. I do not think Institutional Relief differs so very greatly from State Relief as to nullify the experiments that are being tried in this line in our own country. In England the Salvation Army and the Church Army, in Scotland the C.O.S. and the Church of Scotland, are just now busily engaged trying to solve the insoluble problem of creating remunerative work for the unemployed. The experience they are accumulating will be far more to the point than that of Paris in 1848. Yet it will not be altogether conclusive, as I do not think those who manage these enterprises are sufficiently alive to their economic dangers. For years I have been steadily advocating an economic training for all social workers. The pity of it is that in economics as in theology the man in the street knows a great deal better than the expert.

In the second place the Elberfeld method is an elaborate system of subsidising wages. A living standard is fixed. If the head of a family is able by his own earnings to attain to that standard then he is above the poverty line, but if not, his income is subsidised to the subsistence level for himself and his family. The standard is fairly high. Let us take a typical instance. Here is a man, his wife, a daughter of fifteen (working), two between 10-14 at school, two between 5 and 10 at school, an infant in arms. This is a very common family in Glasgow, six living and *six dead*. The man by casual labour earns 6s. a week, the girl 4s. 6d., *i.e.*, the income of the household is 10s. 6d. But according to the maximum scale, the living standard would be, calculating in weeks, 18s. 10d., so that 8s. 4d. would come out of the rates. I am taking the official figures. There may be a countervailing element unknown to me that would reduce this sum. The principle, however, remains the same. Now this is just the Old English Poor-Law on a larger and more fatal scale, the classical instance of the deplorable results of charity divorced from economic principles. And yet it has been in operation in Elberfeld for over fifty years and no one objects to it, and no evils have arisen from it. The Germans have flagrantly broken the most elementary of economic principles for fifty years, and nemesis has not yet overtaken them. So far from wages having been reduced, they have increased by gigantic strides, until now they are on a level with the Trades' Union standard of this country. If I mistake not the labouring wage is higher in Elberfeld than in Glasgow.

Again, if there is one evil greater than another in this country

it is that of indiscriminate giving, and the profits to be derived from a benevolent public by expert begging. Every one who brings a trained intelligence to bear upon work among the poor is agreed that very much of our present charity is worse than wasted, and only serves to deepen pauperism. Now the evil of indiscriminate giving has never dawned upon the German mind. I shall never forget the difficulty we had, when seated at Herr Swanenberg's table in the Armenverwaltung Bureau at Elberfeld, in getting the almoners to understand what we were driving at when we tried to probe the extent of this evil. "Do the almoners never give any relief themselves?" was the question asked. "No, they are not allowed, except in special cases. It is the bezirk that determines the grant." "Not even if they give it out of their own pocket?" A ripple of laughter ran round the Board at the very idea of interfering with any one's private benevolence. This aspect of the question had evidently never occurred to them.

In any question then of transplanting the German system of Poor Relief into our own country, it must never be forgotten that the economic atmosphere is entirely different, and the character of the people is different. For one thing the Germans are more docile than are our people, and take more readily to stringent legal provisions. Further, the problem is not complicated with a degrading drunkenness to anything like the extent with which we are familiar. Moreover, the system is a complete whole; one part dovetailing into another. Such a system as that which prevails in the German cities can only be carried out with the co-operation of the whole community—alike those who relieve and those who are relieved. The worthless, the vicious, the unemployable, must be cleared off the field to start with by the most rigorous tests and the most stringent compulsion. When this is done it is possible you might be left with a body of honest and respectable poor who do not wish to be on the paupers' roll, and who, aided by an efficient band of helpers, would do all in their power to get off it. I can only account for the success of the system at Elberfeld by supposing that there is, at least, an approximation to this state of matters, otherwise it is hard to see how a system which violates generally accepted economic principles should have contributed to make Elberfeld prosperous. For myself I believe in the power of a clear seeing religion and an enlightened morality. I believe, further, that, though it is quite necessary in the field of social

service to have a thorough mastery of the direction in which the individual will go when he follows the line of least resistance, which is the fundamental assumption of economic science, it is not necessary to assume that the individual always will follow the line of least resistance. I believe, in short, that our economic laws are not inevitable, and that in many cases they rather point to dangers to be avoided than enunciate principles to be implicitly acquiesced in.

And if we ask ourselves what Elberfeld has to teach us at the present juncture, we must pause, hesitate and ponder. Elberfeld has much to teach us, but Elberfeld must be digested before it will assimilate itself to the body politic. The principle of enlisting the vast body of enlightened intelligence in the solution of the problem of civic poverty, and of making personal knowledge of and care for the poor the gateway to civic status and civic honours is thoroughly sound. But we must proceed cautiously. The poor have been too long the victims of injudicious experiment. The famous recipe for the making of hare soup begins with the very essential point, first catch your hare. And if you are to institute an Elberfeld system of almoners you must first catch your almoner. I have no hesitation in saying that if you let loose upon Glasgow two or three thousand almoners of the ordinary type of well-meaning people who visit among the poor, to exercise tutelage over those who apply for relief, you would do more harm in a month than you would cure in twenty years. But that is no argument against the system. To be effective we must proceed by degrees, and we must begin by educating our almoners on sound principles of social economics. Why should we not have a practical school of social economics in a great city like Glasgow? I am not thinking of a mere system of lectures, though that would be necessary also, but a clinical school. And why should it not be an indispensable part of a liberal education to have a year's training at such a school? Surely if our business men had a firm grasp of those principles of civic responsibility on which Professor Jones has been lecturing, they would see that their sons and their daughters were as thoroughly versed in practical social work as in the details of business and household management to which they were to devote their lives. Not until such education is far more general than it is can we hope to have an efficient system of almoners on a great scale. But, meanwhile, we might start with the material we have. The process of education has been going

on slowly within those last years. The C.O.S., the various University Settlements, many of our churches have been working on scientific lines and could produce many excellent workers.

Then as to ulterior results for which we must look to legislation. Is the time not ripe for the immediate passing of Mr Motion's Ins and Outs Bill? I have only one fault to find with the Bill, and that is that it does not go nearly far enough, and I am sure Mr. Motion thinks so too. But at all events it is a beginning.

Further, is it not possible to have an enormous simplification of our Local Government? We must have popular government on the broadest popular franchise. But why have three electoral bodies and not one? Why not have one great local parliament elected by the citizens on lines of general policy, and devolve education and the care of the poor to committees with co-opted members? The German system of co-option seems to me to be an admirable idea and quite workable. Surely by some such method as I have indicated, no principle would be violated, considerable saving of expense would be effected, and greater efficiency secured.

But these reforms, if reforms they be, lie in the dim and distant future. What is immediately required is, more light, a wider diffusion of civic responsibility, an increasing readiness on the part of our younger citizens to submit to training and to a painstaking investigation of modern social problems.

Some Facts and Theories Connected with the Inactive Gases of the Atmosphere: Lecture under the Science Trust. By SIR WILLIAM RAMSAY, K.C.B., F.R.S.

[Delivered before the Society, 17th January, 1906.]

ON July 2nd, 1785, the Hon. Henry Cavendish published a memoir in the Philosophical Transactions, dealing with experiments on air. It was there that the first indications of the existence of argon were foreshadowed, nearly a century before its discovery. After passing electric sparks through a mixture of air and oxygen, so as to heat them in presence of "soap lees" (caustic soda) for many weeks, and absorbing the excess of oxygen by means of "liver of sulphur" (potassium polysulphide), he obtained a residue; in his own words:—"Only a small bubble remained unabsorbed, which certainly was not more than $\frac{1}{120}$ th of the bulk of the phlogisticated air (nitrogen) let up into the tube; so that if there is any part of the phlogisticated air of our atmosphere (nitrogen) which differs from the rest, and cannot be reduced to nitrous acid, we may safely conclude that it is not more than $\frac{1}{120}$ th of the whole." The actual number is $\frac{1}{84}$ th; the difference was doubtless due to the solubility of argon in the "soap lees"; for argon is not one of the most insoluble of gases.

On looking over my note-book, it has occurred to me that it might be of interest to place on record some of the early observations, which were not alluded to in the memoir by Lord Rayleigh and myself published in the Philosophical Transactions for 1895. After having received Lord Rayleigh's permission to make experiments to see whether the reason of the higher density which he found for atmospheric nitrogen over "chemical" nitrogen could be traced to the presence of a denser gas in the atmosphere, Percy Williams, then my private assistant, started two lines of research. First, Cavendish's experiment was repeated, the mixture of air and oxygen being confined in a tube which I now show you; but, of course, the much more efficient current from a Ruhmkorff's coil was substituted for Cavendish's cylinder electric machine. It was seen that nitrogen could be "eaten up" by this means, but the rate

was exasperatingly slow. Second, I had noticed that after a lecture experiment, designed to prove that weight is gained by substances burning in air, namely, the setting on fire of some metallic magnesium in a porcelain crucible, that the residue, on standing, gave a smell of ammonia, showing that the metal had combined with nitrogen as well as oxygen. This suggested a mode of attack, which happily proved successful. Williams filled a hard glass tube with turnings of metallic magnesium; it was closed at one end, and communicated at the other with a reservoir of atmospheric nitrogen, drying-tubes being interposed. This was in the middle of May, 1894. In the meantime, I devoted myself to the devising of a method of determining the density of a very small sample of gas. It had been customary to determine the density of gases with the help of large balloons, a device used on the assumption that in order to obtain accurate results, a large quantity of such light substances must necessarily be employed. Experiments made with air showed, however, that reasonably good results could be got with much smaller quantities than two litres. The bulb used contained about 120 cubic centimetres; it is the one which I now show you. The mean of two closely concordant experiments gave as the weight of a litre of air the number 1.2935 gram., instead of 1.2933, the number obtained shortly before by Lord Rayleigh. The difference is only one part in 6,500, which is a very accurate result; indeed, few atomic weights have been determined with that degree of precision.

The density of the concentrated "nitrogen" determined with this bulb, was 14.8, taking as is customary the 16th part of the density of oxygen as unity. The result was encouraging. The month of June was spent in devising apparatus to repeat this process on a much larger scale. A tube closed at one end is not well adapted for the absorption of gas; the portion in contact with the hot magnesium, it is true, is deprived of nitrogen; but it was obviously better to cause the gas to pass over the magnesium, backwards and forwards, so that it might be repeatedly exposed to the absorbing metal. The red-hot magnesium was therefore placed between two large gasholders, one filled with water, the other containing "atmospheric" nitrogen; and, as before, drying-tubes, and a hot tube full of copper oxide were interposed; for it had been found that metallic magnesium gives off hydrogen when heated; and the copper oxide would get rid of that hydrogen as water, to be absorbed by the pentoxide of phosphorus in the

drying-tubes. Between the 10th and the 19th of July, this experiment proceeded, nitrogen being continuously, though slowly, absorbed; and on the latter date, the density of the gas was determined. It was 16.105; hence it was obvious that the nitrogen was increasing in density. My notes for the 20th of July contain the following sentences:—"Dreamed that owing to the dryness of the soda-lime and the gas, it might have consisted of carbonic anhydride, unabsorbed by the soda-lime. Therefore, at once tried it with strong caustic potash solution. No absorption whatever. Hooray!"

After this encouragement, absorption was proceeded with till August 2nd, when a fresh determination of density gave the number 19.09. Apparatus had next to be devised for introducing a specimen of the gas into a vacuum-tube; but the spectrum was not to be distinguished from that of nitrogen. This was disconcerting; so some of the gas was transferred to the old sparking-tube, mixed with oxygen, and treated according to Cavendish's method. This operation was begun on August 6th. At that time, the symbol "Q" was used to designate the unknown gas. On the night of August 6th, the reservoir containing the gas cracked of its own accord; and all the gas except what had been transferred to the sparking-tube was lost! However, that still remained; and after its volume had been reduced as far as it would, a sample was deprived of oxygen, and examined spectroscopically. Its spectrum was new; and the existence of a new gas was regarded as beyond doubt. Making allowance for the contraction suffered by this sample on having been sparked, the density was increased to 19.82.

During these months, Lord Rayleigh was kept informed of the progress which was being made; and he, too, had separated a few bubbles of gas by Cavendish's method, which gave an unknown spectrum.

On August 13th, during the meeting of the British Association at Oxford, Lord Rayleigh and I gave an account of "A new gaseous constituent of Air" to the members of the Chemical and Physical Sections, meeting jointly. I remember that we were asked whether we had not discovered the name of this new constituent; but at the time, though we suspected its nature to be that of an element, we were not certain, and although we took advantage of the presence of many classical scholars at the Association to collect hints, the actual name was not given till

later. I remember that among the names suggested, "atmon" and "krypton" were considered. I think Professor Bonney was responsible for the name "Argon"; but it was not given until the inactive nature of the gas had been confirmed by further experiments. These will now be dealt with.

After the holidays, from October 22nd till November 29th, attempts were made to induce argon to combine with many different elements. Negative results were obtained with oxygen, hydrogen, carbon, chlorine, phosphorus, sulphur, selenium, tellurium, sodium, silicon, titanium, and platinum. Suspecting that argon might belong to the platinum group, filling in the gap before the triad iron, nickel, and cobalt, it was heated with caustic soda, nitre, sodium sulphide, nitro-hydrochloric acid, and potassium permanganate and hydrochloric acid, all of which attack metals of the platinum group. A specimen was sent to Professor Moissan, who was so kind as to expose a mixture with fluorine to the action of a shower of electric sparks, without, nevertheless, effecting combination. Within the last two years, further experiments have been made, as yet unpublished, which consisted in distilling rubidium in argon; in making hydride of rubidium and decomposing it by heat in an atmosphere of argon, and in heating caesium in the gas; but all without avail.

In the original memoir on argon, it was stated that, conceivably, it might resemble the condition which would be exhibited by mercury, were the temperature of our earth higher than 800°C ; for in that case no compounds of mercury would be known; they would all be dissociated. Now, as Deville showed, it is possible to catch a compound, if it be suddenly cooled; and the arrangement of the heated tube, through which a water-cooled tube passed, devised by him, is classical.

All compounds may be divided into two classes; those formed with evolution of heat; and those in which heat is absorbed during their formation. Members of the first class are termed exothermic; those of the second, endothermic. To take an example, ozone is an endothermic compound; it may be imagined that when molecules of oxygen, the formula of which is O_2 , are raised to a very high temperature by the passage of electric sparks through the gas, the atoms which escape out of the hot region combine again with each other. Most of them combine in couples, so as to re-form O_2 ; but some unite to form O_3 or ozone. Moreover, the combination most probably takes

place in the hot region ; for, paradoxical as it may seem, endothermic compounds are more stable at high than at low temperatures. When an exothermic substance like water-gas is heated, it dissociates into oxygen and hydrogen ; and the higher the temperature, the more water is dissociated, till at a sufficiently high temperature, no oxygen and hydrogen are left in combination. But an endothermic substance like ozone becomes more and more stable the higher the temperature, so that at a white heat, oxygen will contain a considerable proportion of ozone. Now, it appeared possible that compounds of argon, if they exist at all, might belong to the latter category, and be stable only at a very high temperature, dissociating on fall of temperature ; and that the only hope of isolating them would be to cool them suddenly, in case some molecules might survive if suddenly removed from the region of high temperature, and kept at such a low temperature, that their sluggish motion might prevent decomposition.

Acting on this supposition, electric sparks, intensified by interposing a Leyden jar in the circuit, were passed through a mixture of argon and oxygen, contained in a glass tube surrounded with liquid air, and consequently at the low temperature -185°C . It was hoped that a non-volatile compound might be formed, which would condense on the cold walls of the tube ; the excess of argon and oxygen would then be removed with the pump, and on allowing the tube to warm up, a mixture of argon and oxygen in definite proportions by volume would result from the spontaneous decomposition of the endothermic compound on warming. But again the results were negative ; all argon and oxygen were removed by the pump ; no trace of a compound could be detected. Helium was submitted to the same treatment with the same result. One of the electrodes was now made of some metallic element, and sparks were passed through argon, still in the cooled tube. Although many metals were tried, including such rare ones as titanium and uranium, the results were still negative.

But another set of phenomena made it not improbable that the theory was correct, though perhaps the correct conditions had not been reached. When a discharge is passed between metallic electrodes through argon under reduced pressure, as in an ordinary vacuum-tube, the metals of which the electrodes consist "splash" much more readily in the inactive gases than

in gases such as oxygen, hydrogen, or nitrogen. Thus, for example, if the electrodes are of platinum, the walls of the tube surrounding the electrodes soon become covered with a metallic deposit. This might be explained by supposing that at the high temperature of the spark a transient compound of platinum and argon is formed, which no sooner escapes from the hot region (for it may be supposed to be volatile) than it decomposes, and deposits its platinum on the nearest object, the walls of the tube.

Again on exposing a mixture of argon and benzene-vapour, with a little nitrogen, and confined over mercury to a rain of minute sparks—the so-called “silent discharge”—so long as nitrogen remains uncombined, the tube is practically non-luminous. But as soon as all the nitrogen has reacted with the benzene, forming resinous compounds which adhere to the walls of the tube, and only argon and mercury-vapour are present, the spectrum of mercury is easily recognised in the strong green light which fills the tube. Here again, it may be supposed that a volatile but unstable compound of mercury and argon is in momentary existence, in sufficient quantity to exhibit the spectrum of mercury.

An attempt was therefore made to “splash” various metals in argon and helium, and to examine the deposit for the presence of compounds of these gases. The deposits, however, contained only the pure metal, whatever that was. I then suggested to Mr. W. Ternent Cooke that it might be possible to obtain evidence of the existence of such compounds if the vapour-density of some elements were determined by the elegant process devised by Victor Meyer, at a high temperature in an atmosphere of argon or helium.

The principle of Victor Meyer's process is this :—A bulb at the lower part of a tube is heated to a high temperature, higher than the volatilizing-point of the substance of which the vapour-density is to be determined. The upper part of the tube has a device attached, by means of which it is possible to project into the bulb at a given moment a weighed fragment of the substance of which the vapour-density is required. When this is done, the substance suddenly vaporizes, and the vapour expels its own volume of air through a side-tube sealed at right-angles to the top of the vertical tube; this air is collected over water, and measured. From a knowledge of the weight and volume of the vapour, it is easy to calculate its density. This, of course, is on the supposition that the vapour does not combine with

the gas in the tube. If it does, and the product is a gaseous one, it is nearly certain that contraction will take place, and the density of the vapour will appear too high.

In Mr. Cooke's experiments, the tube was made of silica-glass, which stands a temperature of 1500°C , without deforming. The actual temperature employed was reached by means of an electric furnace, and was about 1200° or 1300°C . From his experiments, it appears that the elements selenium, zinc, and mercury, when volatilized in argon or helium, give a higher vapour-density than when volatilized in nitrogen or hydrogen; and at last, it may be concluded that the reasoning is correct, and that compounds of the inactive gases are stable, and capable of existence at a very high temperature.

The amounts of the rare gases in air are, with the exception of argon, very small. Experiments which I have made recently show that neon, the next most abundant, is present only in the proportion of one part in eighty-one thousand of air; helium, one part in two hundred and forty-five thousand; while the amount of krypton and xenon are excessively minute; they are respectively fourteen, and two and a half parts in one hundred million.

That questions such as those which I have brought before you have a cosmical bearing is shown by a recent paper by the American astronomer, Mr. T. J. J. See, published in the "*Astronomische Nachrichten*." He believes that at the enormously high temperature of the sun, which at the surface is at least 6000° , and may well be $12,000^{\circ}\text{C}$., and which is enormously higher in the lower regions, all elements must necessarily exist as gas; and all gases must exist in the state of atoms, none being combined so as to form molecules of a greater complexity than one atom. On the supposition that the molecules are diatomic, like oxygen, the somewhat incredible deduction appears necessary that the density of the centre of the sun must be approximately twenty-eight times that of water; and this estimate has been practically confirmed by Lord Kelvin, than whom no better authority exists. But if all gases are imagined to exist at the high temperature of the sun in the state of the gases of the argon group, that is, where the molecules are single atoms, then the calculation gives a much more reasonable number for the central density, namely, 8.42 times that of water. On the other hand, Mr. See has not taken

into consideration the possibility that at such high temperatures, compounds of the argon group of gases may in reality become more stable than they are at the highest temperatures which we can produce on this earth ; and the real density at the centre of the sun may be higher than the number which he gives.

Again, the heat of the sun does not appear to be a decreasing quantity ; and it has been suggested that its continual supply is due to the disintegration of radium and similar elements ; the final product, it will be within your recollection, was discovered by Mr. Soddy and myself to be helium, an element plentiful in the sun, to judge by the intensity of its spectrum in the chromosphere of the sun. This source may not be excluded. But accepting Mr. See's calculations, and his premiss that at all events a large proportion of the elementary matter in the sun is monatomic, it would appear that there is a plentiful reserve of heat in the sun to maintain it at its present temperature for at least ten, and probably thirty million years.

Social Reformation of Criminals. By Bailie JOHN BRUCE MURRAY.

[A Paper read before the Society, 31st January, 1906.]

As civilisation advances it brings about many changes in ideas and sentiments. These changes are very marked in criminology. To such an audience as this it would be superfluous to dilate on the views and methods that obtained little more than a generation ago, when the ruling idea was that crime could be repressed by severity of punishment, amounting in some instances almost to barbarism. This state of affairs has given place to lenity, and so prevalent is the belief that our offenders and criminals are now justly and mercifully dealt with, that on this question the attitude of the public generally may be said to be either acquiescent or apathetic. Great progress in criminology has certainly been made, but there is still much to be desired, and in point of fact we, who for so long may be said to have been in advance of any other people in dealing effectively and humanely with crime, have in some important points fallen behind other countries, notably the United States. While this distinct inclination towards a clemency, amounting sometimes almost to undue toleration, may be observed in our views of crime and our treatment of criminals, minor offenders are in many respects still treated with undue severity and want of consideration.

As regards the graver offences, the former tendency may be perceived in the comparative levity with which certain crimes are regarded by the public, as indicated by the press. Take as an instance clever theft or daring burglary. The bold deeds of the burglar are occasionally celebrated in verse, even in reputable journals, and are made the theme of successful and popular novels. At the Newcastle Court the other day a young man admitted that he had been induced to commit housebreaking by the spirited description of a burglary in a local journal under the heading of "Cracking a Crib." Some of our lower class journals are special offenders in this respect, and their influence as an incentive to crime cannot be regarded as other than highly prejudicial.

This tendency towards toleration and consideration is mani-

festes by humane treatment in prison—the modern idea being that imprisonment should be made reformatory rather than punitive or deterrent. In fact, apart from deprivation of liberty, jails now afford much more comfortable quarters and better food than the majority of prisoners are accustomed to in ordinary life. The older methods of the treadmill and flogging are practically abolished, and the general result is that imprisonment, once experienced, loses much of its terrors.

On the other hand, as regards undue severity, the prevailing belief that all offenders and criminals now receive equitable, humane and even sympathetic treatment, is hardly borne out by the administration of justice in our Lower Courts, which is frequently unnecessarily severe and lacking in consideration for individuals and their dependents. This is shown in a variety of ways. Offenders are brought before what are well-termed Courts of Summary Procedure. In the Police Courts of Glasgow alone on an average nearly 1000 cases per week are dealt with by the five Magistrates appointed for this duty—for the week ending 6th January, 1906, the number amounted to 1652—and on busy days it is said that sometimes as many as 90 cases have been disposed of by a single Magistrate in one hour. True, many of these charges, such as those in which pledges are forfeited or guilt admitted, need occupy little time, but on the other hand, there must be a number of cases in which careful consideration and investigation are not only desirable but necessary. At this point I should like to make it clear that no imputation is made against either the Magistrates or Police Authorities throughout Scotland, all of whom, so far as my observation goes, are anxious to deal as carefully and sympathetically with offenders as circumstances will admit. But circumstances and traditions are against them, and with the enormous amount of work to be got through every week in our Police Courts it is certainly very difficult to avoid procedure more or less rapid and summary. There is a popular impression, not wholly inexcusable, that those brought up in the Police Courts are guilty, or otherwise they would not be there, and are likely to get only what they deserve in the way of punishment. One worthy Magistrate, deceased, used to say that in cases of doubt as to guilt he always gave the *public* the benefit of the doubt. Undoubtedly in some instances prisoners get a good deal less than they deserve, and more severe punishments are imperative in the interests of public order.

Now amongst the large number of persons thus summarily dealt with there must be some who have the misfortune to suffer from this hasty procedure, who are convicted and sentenced without that careful trial under trained judgment which obtains in the Higher Courts, where prisoners have in addition the benefit of Counsel. In only a very few cases are offenders represented in the Police Courts by Agents ; and although the Assessors endeavour to assist and guide the accused they also must be more or less influenced by the conditions just described, and, having like the majority of Magistrates their own business to attend to, are naturally inclined to fall in with the general desire to expedite proceedings. Many of those brought into Court for the first time are apt to be bewildered by the surroundings, and, being totally unacquainted with the procedure, not unnaturally believe that they may safely leave themselves in the hands of the Magistrates ; and, it being contrary to the spirit if not the letter of our law to question an accused person, nothing is said for them. They frequently say little or nothing for themselves. Indeed one cannot but be struck by the contrast between the proceedings in the High Courts and those in our Police Courts. In the Higher Courts cases in which the sentence may be only a few days imprisonment are dealt with slowly and methodically, with the aid of a jury and by a trained judge ; whereas in the Police Courts charges involving sentences of two months, and, under the Further Powers Act, up to one year with hard labour, are disposed of by a Magistrate, who has no legal education, whose experience on the bench is necessarily short and intermittent, who is in himself both judge and jury, and who cannot have that skill in weighing evidence which can alone be acquired by training and experience, and which is indeed all the more necessary in a Court where the proceedings are more hurried and less formal. I refer to this because it illustrates an anomaly which is very striking. Prisoners brought before the High Courts are for the most part persons whose offences have been aggravated by previous convictions, and who are not likely to be much affected in either reputation or character by renewed imprisonment, while, on the other hand, those accused for the first time, and whose whole character and reputation are at stake, are tried by an untrained judge, and in the summary manner just described.

Then as regards punishment, there is a tendency towards undue severity in the infliction of fines with the alternative of

imprisonment. Although the punishment of certain crimes or offences by either fine or imprisonment is decided by the Magistrate, in the great majority of offences under the Police Acts the option of paying a fine or going to prison rests with the panel. A person who has money or friends to assist him is enabled to escape imprisonment by immediate payment, while a less fortunate individual who may not have friends at hand, or may not be able to find at once the required amount, is within an hour or so transferred in "Black Maria" to Barlinnie. I need not give illustrations of the hardships of this system, say in the case of two men charged with the same offence, but it is obvious that a man without money suffers a grave injustice, and, as has been well said, goes to prison because of his poverty and not for his crime. In point of fact a rich offender may get off for repeated offences by forfeiting pledges, and without ever having to appear in Court, while his poorer fellow delinquent, summoned or arrested, it may be for the first time, has to go to prison. The hardship entailed by this method of procedure has been to some extent recognised, and an attempt to mitigate it was made by the institution a short time ago of an arrangement whereby a prisoner sent to Barlinnie for say five days in default of payment of a fine, can secure his release, during this period of confinement, by payment, under deduction of a proportionate amount for each day he has been in custody. This is certainly an improvement, and last year out of about 16,000 persons sent to prison from the Glasgow Courts in default of immediate payment, 4112 were enabled by this concession to obtain their liberty before completing the full term of their sentence. In the Report on the Judicial Statistics of Scotland for 1904, the Commissioners point out that over 43,000 persons in Scotland, sentenced to pay fines, were received in prison because they did not possess the required sum. Why should this be so?

There is an absolute consensus of opinion on the part of all qualified to judge that imprisonment in the case of short sentences is not only neither deterrent nor reformative but positively detrimental, and it appears almost unnecessary to point out the prejudicial effect such treatment must have in many ways upon the individual concerned. He or she not only suffers in reputation but in many cases as a consequence of the disgrace, is deprived of employment, with the resultant hardship upon families and dependants. Indeed it is pitiful to think of the

straits to which households are frequently reduced by their efforts to realise a sufficient sum to release the breadwinner. Experience teaches that imprisonment tends to render people more reckless and abandoned. This is very particularly the case with regard to women ; and in the Report of the Departmental Committee on Habitual Offenders, presented to Parliament in 1895, attention was very forcibly drawn to the evils resulting from this wholesale resort to imprisonment, which might under other conditions have been avoided. According to the Judicial Statistics the numbers imprisoned in Scotland during 1903 were 59,962, or 1 prisoner in 75 of the population, as against 1 prisoner in 145 of the population in England and Wales in that year. About four-fifths of those imprisoned in Scotland in 1904 were sentenced to pay fines, but owing to want of money had to go to jail as the alternative of the sentence. The Commissioners consider it very inadvisable that any person should be sent to jail except with the view to substantial punishment, and that the prevailing practice of sending men and women to prison without allowing them a reasonable opportunity of raising the money should be discouraged. In this most valuable Report, which does not seem to have received the public attention it merited, it is also pointed out that the law, in imposing a fine as a penalty for an offence, and prescribing imprisonment only in default of payment, evidently meant to mitigate and not to aggravate the punishment, for it authorises Magistrates to give time for the payment of a fine, to accept securities for it, or to order its payment by instalments. But notwithstanding this most reasonable provision the Commissioners say that owing either to some defect in the machinery, or in the law which confers this power, or to intentional or unintentional disregard of its provisions, so far as the Police Courts in Scotland are concerned it is practically a dead letter. This extraordinary fact is, on the face of it, not at all creditable to those concerned in the administration of justice. It appears to be mainly due to ignorance. To some extent it may also be attributable to doubt as to legal powers, or to a desire to avoid the increased trouble and expense which the free exercise of such powers would probably involve.

Referring for a moment to the case of drunkenness, all evidence tends to shew that short imprisonment sentences not only have no reformatory influence on drunkards but often have most deteriorating effects. Here again comes in one of these anomalies

connected with our Police Courts which at once strike an observer. The sitting Magistrates vary from week to week as has been said—it may be from day to day—and there is a marked difference in their views, especially in cases of this nature. Some Magistrates believe that drunkenness can be, and ought to be, suppressed by heavy punishment. They impose fines, say of 7s. 6d. or 10s. 6d.—where the offence is repeated sometimes much more—with imprisonment in default of immediate payment, and without due and sufficient regard to ability to pay. In say twenty cases dealt with at the same Court a uniform fine of 7s. 6d. must operate very inequitably, as for instance in the case of an artisan and a labourer. What proportionately may be a very light fine in the one case may be a very harsh punishment in the other. For instance 7s. 6d. may represent half the small weekly earnings of the latter, and such a person realising the difficulty if not the impossibility of raising the money at once, elects to go to prison. He goes, finds it not such a bad place as he anticipated, comes out more or less discredited, and less inclined, if he should again fall, to make any effort to avoid incarceration.

It is undoubtedly a difficult and delicate matter in our hurried procedure to discriminate among those charged with the same offence, especially when there is little or no information as to character and circumstances to guide the Magistrate. This is another instance where more considerate and lenient treatment might be adopted with advantage to the individual and a saving of expense to the State. Of course the alternative sentence of imprisonment might ultimately have to be enforced, but if time were given for payment of judiciously graduated fines, either in full or by instalments, the punishment, while not less efficacious, might be more felt. It is certain that thereby large numbers would be saved from baneful familiarity with prison life, and a disgrace would be removed from the statistics of imprisonment for Scotland.

Enough has been said, without giving further instances, to justify the charge made in the Report of the Committee on Habitual Offenders, and in the Report of H.M. Prison Commissioners, that a large number of persons are needlessly and often harshly sent to prison, with expense to the country and detriment to the individual. With such evidence before us it is impossible to get away from the fact that prompt imprisonment is still looked upon in our Lower Courts in Scotland as the main method of

dealing with offenders, and this, notwithstanding the fact that, under existing statutes, so much can be done both in the way of punishment and reformation without having recourse to incarceration. This is the more remarkable in view of the constant addition of new offences, created by the ever-increasing legislation deemed necessary by progressive communities, of which Glasgow may be taken as a prominent example. The Americans, as humane and sympathetic as ourselves, but less bound by tradition, were the first to realise that offenders could be effectively dealt with and reformed out of prison ; and in Boston the first practical steps, so far as I have been able to ascertain, were taken with this object, by the institution of what may be termed generally "conditional release on probation under guardianship and supervision."

The success which attended the experiments in the State of Massachussetts led in this country to the Probation of First Offenders' Act, which was introduced into the House of Commons by Colonel Sir Howard Vincent in 1887 and became law on 1st January, 1888. The object of this Act is to give power to a Magistrate to release an offender on his own recognisances, to come up for judgment if called upon, when it may appear to the Court that, having regard to the youth, character, and antecedents of the offender, the trivial nature of offence, or of any extenuating circumstances, there is a probability of reformation. But in the words of the promoter, this Bill as introduced, and as sanctioned by the House of Commons, contained a clause enabling Courts of Assize, Quarter Sessions, as also Courts of Summary Jurisdiction, to appoint Probation Officers to inquire into the antecedents and situation of the persons charged, to report thereon to the Court, and to care for any person convicted of crime whose sentence was suspended, and report to the Court concerning his conduct and efforts to reform. This clause containing so valuable an incentive and aid to reformation, and so necessary to prevent the clemency of the Court being abused, was most unfortunately thrown out by the House of Lords, on the ground, broadly speaking, that such supervision would be subversive of the liberty of the individual. And, strange to say, there is still strong opposition to any provision for conditional release under guardianship, on the singular ground that offenders would not like it, apparently forgetting that in most cases the only alternative would be imprisonment. Many offenders certainly would

prefer to expiate, as they think, their offence either by money or temporary loss of liberty and have done with it.

The Probation of First Offenders Act has been largely taken advantage of, more particularly since a circular was issued by the Home Office in 1892, recommending the more general adoption of its provisions, and a large percentage of those released have given no further trouble. On the other hand, the absence of any adequate arrangements for control after the prisoner leaves the Court not only leads in many cases to the clemency shown being abused, but naturally makes the Magistrate hesitate to give the prisoner the benefit of the Act when he fears uncontrolled or unsupervised liberty might be ineffectual, and even harmful to the public. Under this Act all that a Magistrate can do is to bind over the accused to come up for judgment on a certain day if called upon, when, if he has committed no offence in the interim, he is released. The ordaining of a prisoner, released under an obligation to appear in Court on a certain day—say three months' afterwards—would undoubtedly have a controlling effect, but in the administration of the Police Acts in Glasgow it has been held that a prisoner cannot be brought back into Court again except for a new offence, and this valuable provision, exercised elsewhere—as, for instance, with most satisfactory results in Dundee—has been in abeyance. This reading of the Act has greatly weakened its utility, the offender being practically set at liberty and free to resume his old companionships and habits of life, so long as he can avoid detection anew. In cases where a prisoner is released under promise to accept assistance voluntarily offered by philanthropic institutions or individuals, the want of some power of control is greatly felt. Instances frequently occur where a promise made to the Magistrate is broken almost as soon as the prisoner leaves the Court. This is a subject upon which much might be said, did time permit, but it is obviously impossible to do so within the limits of the paper.

The Magistrates and Town Council of Glasgow, about a year ago, had their attention strongly directed to the successful operation of Probation Guardianship, as shewn by its extension throughout the United States of America, and its adoption in Canada and other countries. A Special Committee was appointed to look into the matter, and to ascertain how far such a system could be instituted here under our laws. After full enquiries, and consultation with those actively engaged in the

prosecution and treatment of offenders, and in the administration of justice ; and after consideration of an able report by Mr. John Lindsay, Depute Town Clerk, as to what could be done under existing statutes, the Committee made certain recommendations, which were adopted by the Town Council on the 8th of December last. The Minutes containing the full report of the Committee have been printed, and the valuable information and expression of expert opinion given therein are no doubt well-known to those interested in the subject. The resolution of the Corporation to appoint Probation Officers, to be selected from the Police Force by the Chief Constable, and to act in plain clothes, and the recommendations to the Magistrates in regard to the infliction and payment of fines, and conditional liberation, also in regard to the treatment of Juvenile Offenders and their trial in separate courts, have been published in the press. It is therefore unnecessary to enter into details. Full effect will soon be given to the recommendations as to children, which have occasioned little controversy.

A Probation Officer is now in attendance at each of the nine Police Courts in the city, and it is to be hoped that the recommendations of the Town Council just referred to, particularly as to the use of imprisonment, will be generally adopted by individual Magistrates in the exercise of their duties on the Bench. Indeed the report of the Committee, and the arrangements for supervision, have already begun to take effect, and in several cases Magistrates have availed themselves of the powers to which their attention has been called, and have placed several prisoners on probation.

The next step will be a Conference with the various Institutions, Philanthropic Societies, and others willing to help in the care and reformation of offenders, and to work in conjunction with, and under the direction of, the Probation Officers. These arrangements, when complete, will be in advance of anything yet attempted in this country, and will enable the Magistrates to give prisoners whom they deem hopeful every opportunity to reform under the best conditions compatible with our present legal powers. It is to be hoped that the action of our city in this respect will lead to the adoption of similar arrangements throughout the country.

It was found in America that the general institution of the Probation System materially conduced to its success. For in-

stance, offenders promising to leave vicious surroundings and to return to their homes, or remove to the country or elsewhere, are there transferred to the care of Probation Officers in the other districts, through whom arrangements are often made to admit of a fresh start in life. This obviates the difficulty often felt in releasing a prisoner under promise to leave his or her old haunts, but for whom without some such assistance circumstances might prove too strong.

The success of the system locally will mainly depend upon the tact and discretion displayed, especially at first, and on the spirit in which the recommendations of the Town Council are adopted and carried out by individual magistrates. It is useless, however, to disguise the fact that many difficulties and much opposition, more or less open, will have to be overcome. There is what may be termed a very strong conservative opposition on the part of those who believe that the present system, if not all that could be desired, is at anyrate all that is practicable. Many object on the score of the expense that may ultimately be incurred, not so much in providing probation officers as in the extra labour involved in giving full effect to the recommendations as to fines and deferred sentences. Indeed, exception has already been taken to the small extra sum allowed as payment to the probation officers in lieu of uniform. But surely in a community so noted for generous philanthropy, no question of reasonable expense will be allowed to stand in the way of a scheme, which, if successful, will not only save much needless suffering, but will help to prevent numbers of our fellow-citizens from drifting into the already large and increasing body of almost incorrigible criminals in our midst.

Notwithstanding the opinion that has been expressed that the powers under existing laws are sufficient, it is to be feared that the success of the experiment may be further imperilled by the want of the legal powers which have mainly brought about such good results in America. There is a marked difference between the position of the probation officer in American courts and in our own. In the first place, the probation officer there is able, without any warrant, to have the offender brought before the court at any time during the period of probation in the event of his behaviour not giving promise of reform, and the court may then proceed to sentence, or, if deemed advisable, to admonish and release again on probation. Under our law this

apparently cannot be done, and while a probation officer may try to control or help the persons placed under his supervision, a culprit cannot be interfered with before the day upon which he has been ordained to come up for sentence. This drawback and its probable effect upon the probationer are very obvious, and must lessen the influence of the probation officer. On the other hand, the knowledge that prompt measures would be taken in the event of misbehaviour would exercise a wholesome restraint. This would also be much more satisfactory to magistrates. Penitence at the bar is very common, and if its sincerity could be tested under conditions that would ensure that any abuse would be promptly dealt with, Magistrates would naturally be more inclined to give prisoners the chance they often ask for. But it is obvious that the system must not be applied in a wholesale manner, so as to be regarded as a matter of course, nor must offenders put on probation be allowed to form the impression that they will thereby escape punishment if the conditions of release are not observed. It is inevitable that many failures must occur; but, even in this event, society will at least have the satisfaction of knowing that imprisonment was the only alternative possible; and it would be desirable that those who have failed to make good use of the opportunity given them to reform should be smartly dealt with.

A further advantage is possessed by the probation officer in America in having assistant guardians, male and female, appointed by the court, frequently from the representatives of philanthropic institutions. Some of the churches in America maintain an assistant probation officer at their own cost, and ladies and gentlemen often voluntarily place their services at the disposal of the court. The direct intervention of the official guardians in many cases is thus unnecessary so long as satisfactory reports are received. The appointment of female probation officers has been found most advantageous. It is to be hoped that in our courts this method will be adopted as far as possible; but without the power of restraint possessed in America the system can never be so efficient.

Although the principle of probation has been so generally adopted in America, the manner and extent of its application differ in various States, and even in localities. Probation is a system essentially dependent upon sympathetic administration, hence its success is not uniform throughout the country. Where

it is encouraged by the Court, heartily carried out, and above all supported by the people, the results are excellent. Where the Court or the people are indifferent it is apt to be neglected or carelessly administered, if not actually abused.

In many respects the American methods are in advance of our proposals. What may be called the reformatory department of judicial administration is there kept quite distinct from the Police, whose primary business is to detect and repress crime. The duties, the training, the qualities physical and moral, of an efficient officer of Police, even the position he occupies, do not readily lend themselves to the gentler methods of moral suasion required of a Probation Guardian, whose main object is reformation. It is undoubtedly desirable in the interests of an offender to avoid the overt intervention of the police. Hence the decision of the Town Council that Probation Officers shall not wear uniform. At the same time the qualifications desired in a Probation Officer are by no means incompatible with a training in the Police Force, which ensures a knowledge of offenders and their surroundings not easily acquired otherwise. It is fair to say that, so far as my personal experience goes, the Glasgow Police on the whole, and the higher Officers in particular, manifest a disposition as considerate as it is commendable. Most efficient Probation Guardians may be selected from their ranks; but in my opinion the reformatory officer should not be regarded as an active member of the Police Force. The object at which he aims is essentially different.

Then the American method provides for enquiry and investigation into antecedents and circumstances, the lack of which is often so seriously felt by our Magistrates when passing sentence. The Probation Officer supplies this defect in America, acting in a sense as a lay advocate for the prisoner. But with our ideas of criminal procedure it is thought improper for the Police Authorities, or indeed anyone short of a legal adviser, to question an accused person. I do not know how far it may be permissible for our Probation Officers to make enquiries and investigation, but I do know how invaluable such information would be to the Magistrates, a number of whom must always be more or less inexperienced and new to the work. This is where the civilian Magistrate and the Probation Officer are alike at a disadvantage in great cities. In older days when communities were smaller, the lay Magistrate possessed himself, or could easily

obtain, information as to the character and surroundings of each offender. He could be safely trusted, therefore, to administer justice in a rough and ready fashion suitable to the exigencies of each case. But modern conditions in great cities are entirely different. They demand a skill and legal ability possessed by few citizen judges, and it is a matter for grave consideration whether the time has not arrived when such numerous and complicated offences should not be dealt with by legally trained judges sitting continuously. It is not uncommon to have as many as three or four different Magistrates presiding over the same Court in one week, with the consequent lack of any continuity of experience and policy. Indeed the day cannot be far distant when, if for no other reason, the growing demands upon the time of the Magistrates will make relief from judicial functions imperative.

The subject of criminals and their treatment has been discussed by this Society on several occasions. We had recently most interesting papers by Dr Devon and Police-Superintendent Douglas specially dealing with imprisonment and its effects. Our leading sociologists have long advocated more rational methods. Since 1888 practically no change of any importance has been made in our laws or in their administration. The time is ripe for amendment. Little or nothing can be done, or will be done, unless under pressure of public opinion. The successful inauguration of the arrangements, and the adoption of the recommendations made by the Town Council, depend upon this far more than most people would imagine. Without such support and encouragement the old ideas will prevail, and progress will be impeded by those who regard any interference with individuals, beyond the ordinary powers of the police, as espionage and subversive of British liberty, despite the fact that the only alternative may be total deprivation of freedom.

I cannot pretend to write a scientific paper on Criminology, but I gladly availed myself of the opportunity offered by the Committee to direct the attention of the Royal Philosophical Society to a question so vitally affecting the whole community. The influence, the views, even the suggestions of such a body, are most important; and my apology for appearing before you to-night is the hope that this paper may help to enlist sympathy and secure aid in support of what, after all, is but practical Christianity.

The Necessity for Improved Ventilation of Buildings. By NEIL CARMICHAEL, M.D., F.F.P.S.G., Examiner in Public Health, and State Medicine, Faculty of Physicians and Surgeons, Glasgow.

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WHEN man lives in the open he need give no consideration to ventilation. He has pure air to breathe, and the air which he expires passes off freely into the surrounding atmosphere and is not breathed again. In a room or other inclosed portion of a building the expired air tends to accumulate, and unless special provision is made for frequent renewal of the air, he breathes again a portion of the air which he has already breathed. The air of the apartment becomes foul, and hurtful to health. Air is a prime necessity of life. Life without air can only continue for a few minutes. Air is the most important part of the food on which man lives. Each person breathes from 30 to 40 pounds weight of air per day. No other food is taken in such quantity. Of the air taken into the lungs, oxygen to the amount of 30 ounces is taken into the blood per day. This oxygen is required for combustion in order to provide heat and energy for work, as well as for the upbuilding and the renewal of tissue used up in doing work. To supply the needs of the system the air breathed must be pure and abundant. Air which has been breathed is no longer pure, it is indeed poisonous. Pure air contains from 2090 to 2099 parts of oxygen per 10,000. This is the food part of air. Air contains 7900 parts of nitrogen, which, so far as we know, is inert. Air contains from three to four parts of carbonic acid per 10,000. This is the invisible smoke of the human furnace. Pure air contains a little ozone—one part in 700,000 at most. Such is pure country air. The air of towns contains a little more carbonic acid, usually about five parts per 10,000. It contains no ozone. Town air also contains nitrous acid, nitric acid, sulphuric acid, chlorine, sulphuretted hydrogen, and other products of coal combustion and of chemical manufactures. Besides these chemical

products, air contains also solid particles of various kinds—such as soot, particles of incompletely consumed coal, fibres of wool and cotton—microbes and moulds. The air which man expires contains 400 parts of carbonic acid per 10,000, *i.e.*, a hundred times as much as pure air. It contains 17 instead of 20 to 21 parts of oxygen. It is saturated with moisture, and it contains organic vapours.

In inhabited rooms the principal impurities are excess of carbonic acid, organic vapours from lungs, skin, clothing, and the organic materials in the apartment, also microbes and moulds. In addition to the impurities just referred to, there is also a large quantity of moisture given off. The air breathed out is at a temperature of 98° F., and is saturated with watery vapour. By skin and lungs a man gives off about two pounds weight of water per day, that is about $1\frac{1}{3}$ ounces per hour. In inhabited apartments, if there were no ventilation, the atmosphere would soon become fatally poisonous. But, thanks to the porosity of building materials, and to the blessed imperfections of workmanship, air passes through the walls to some extent, and through chinks and crevices to a considerable extent, and so prevents the occupants destroying themselves. Suppose, as illustration, we take a room of 10,000 cubic feet capacity, and that in this room there are twenty persons. Each person has 500 cubic feet of air space. The air of this room, when pure, contains 4 cubic feet of carbonic acid. Each person exhales 16 cubic feet of carbonic acid per hour. At the end of one hour, if no fresh air entered, the apartment would contain 16 parts of carbonic acid instead of 4. At the end of two hours it would contain 28 parts. And if used as a dormitory, at the end of six hours it would contain 72 parts.

This condition is, of course, never reached. Hot, foul air finds imperfect outlets, and air more or less impure enters by chinks and crevices, by keyholes, by skirting boards, and by seams of doors and windows. Air does enter, but frequently far from pure.

But although there is a certain amount of air entering, and some foul air passing out, the condition of the atmosphere of occupied apartments is frequently so bad as to be a danger to the health and the life of the inmates.

Single apartment houses are rarely provided with any special means of ventilation, with the exception of a chimney which is not infrequently closed.

Bedrooms of larger houses, as regards their ventilation are frequently very bad. The window is too seldom kept open at night. The chimney does something to extract air, and chimneys let in a little air from somewhere. The resulting conditions are very unfavourable for health. If one enters an average bedroom in the morning, the foulness of the atmosphere is obtruded on the organs of smell. This atmosphere breathed during sleep (a period of one-third of the total life) is not such as to sustain vitality at its best. It is rather such as to cause imperfect cleansing of the blood and tissues, and an accumulation of effete material in the system. This is indeed the condition which renders the system a suitable soil for many diseases, especially consumption. Pure air is required during the night not less than during the day, and pure air cannot be obtained in a bedroom which has door and windows closed, unless some other free inlets and outlets for air are provided. Breathing cold air is not in the least injurious night or day, if the body is kept warm. We are provided with nostrils to warm the air which we breathe. No one catches cold from breathing pure air. Even consumptives with diseased lungs may breathe air ice cold without any injurious effects following. There is a curious superstition abroad that the breathing of night air is injurious. What other air can be obtained during the night it is impossible to conceive. The worst of outside air is better than the best bedroom air which has been already breathed. The fear of draughts prevents many from opening their bedroom windows at night. A draught is a current of air rushing at a rapid rate into an atmosphere which is usually warmer than the incoming air. The more rapidly the air enters, and the lower its temperature as compared with the temperature of the air of the apartment, the more objectionable becomes the draught. Air entering an apartment through a small opening, travels as a bolt or jet, and striking on one part of the body while the rest is enveloped in warmer air, produces a feeling of chill, while air entering through a large opening travels more slowly, not as a jet or bolt, but as a gentle breeze, diffuses itself through the air, and does not tend to chill. When there is a draught in a room heated air must be escaping at some point—perhaps the chimney. The place of this escaping air must be supplied by air entering from without. If the openings admitting this air be small in proportion to the amount of air entering, then the rate of travel must be rapid, and so a draught is created. The cure for

a draught is not to stop up the chinks, but to admit air freely by wider openings, so that the required amount of air may enter travelling so slowly as not to cause an offensive draught. If you close a few chinks you cause the air to travel in, more rapidly from other, probably more undesirable, openings.

Bedrooms are sometimes ventilated by keeping the door open. This is better than nothing, but ventilating from corridors or hall: of houses which have all outer doors and all windows closed is not a satisfactory way of obtaining a supply of pure air.

The remarks just made concerning bedrooms apply also to sitting rooms. A parlour, dining room, or drawing room, well occupied or perhaps crowded, if no special provision is made for ventilation, becomes in a short time foul from accumulation of lung and skin excretions. The atmosphere becomes warm, moist, and impure. The heated atmosphere seeks to escape by every possible outlet, and every chink admitting fresh air creates a draught. If the air is to be maintained in reasonable purity, inlets for pure air must be provided, and if draughts are to be avoided the inlets must be sufficiently large to permit the air to enter slowly, and they must be so placed as not to conduct the air directly on the overheated occupants. Outlets also are necessary in addition to the chimney, if the room is crowded, and especially if gas is burning.

Schools are frequently hurtful to the health of teachers and scholars from foulness of atmosphere. Schools are variously ventilated and unventilated. In some schools it is considered quite sufficient ventilation to open the windows for a few minutes at the end of each hour. This is, of course, quite insufficient. Some schools are ventilated by keeping one or more windows slightly open during class hours. This, however, calls down all manner of objection from fearful parents, who send to the master peremptory orders to keep the windows closed. Some schools have wonderful arrangements of cowls, more or less fantastic, whose duty is supposed to be the extraction of foul air even when inlets are not provided. In some cases these cowls do extract, especially when the wind is blowing freely. But when the outside air is close and steamy, that is, when ventilation is most wanted, they do not act. When there is an active fire in such a room the cowl may act as an inlet, sending down a douche of cold air. Many schools now are mechanically ventilated, some by propulsion, some by extraction, some by a combination of these methods.

The mechanically ventilated schools are much healthier than the others. The plenum and the extraction systems have their advantages, and much may be said in favour of each. Both systems have been found to yield satisfactory results.

Workshops are frequently very badly ventilated. There are windows which might be opened, but to this the workers usually object.

Carbonic Acid. Parts per 10,000.	39 Work- shops.	
6—10 - -	- 4	Tailors, Restaurateurs, Kitchens, Costumiers, Jewellers, Calenderers, Bootmakers, Dressmakers, Printers, etc.
10—15 - -	- 8	
15—20 - -	- 11	
20—30 - -	- 8	
30—40 - -	- 7	
46—... - -	- 1	

The condition of thirty-nine city workshops as to atmosphere, tested and reported upon by the sanitary department showed the condition to be exceedingly bad. Of the thirty-nine four had reasonably pure air, eight had decidedly impure air, all the rest had an atmosphere so impure as to be seriously dangerous to health, and altogether indefensible. That the conditions are capable of improvement, that indeed the atmosphere of such places can be maintained of reasonable purity, is made evident by the results obtained in forty-three underground bakehouses into which ventilation by means of extraction and propulsion fans was introduced by compulsion of the sanitary department.

Carbonic Acid. Parts per 10,000,		
4—5 - -	- 3	43 Underground bakehouses after introduction of mechanical venti- lation.
5—6 - -	- 9	
6—7 - -	- 22	
7—8 - -	- 8	
8—9 - -	- 1	

In all the forty-three the atmosphere was pure. In workshops and factories it is not desirable to trust to the opening of windows by the occupants. Measures should be adopted which will secure a continuous supply of pure air.

Theatres are as a rule very imperfectly ventilated. I have made examination of the air of some of the Glasgow theatres.

Theatres.	Temperature.	Carbonic Acid per 10,000 parts of Air.
A—Private box, - - -	63° F. - - -	21·9
Pit, - - -	70° F. - - -	18·5
Amphitheatre, - - -	75° F. - - -	23·1
Gallery, - - -	75° F. - - -	32·2
B—Private box, - - -	55° F. - - -	25·2
Pit, - - -	55° F. - - -	10·8
Amphitheatre, - - -	65° F. - - -	28·2
Gallery, - - -	61° F. - - -	26·4
Public Halls.		
A—Near organ, - - -	70° F. - - -	36·3
Area, - - -	72° F. - - -	24·1
Gallery (back), - - -	76° F. - - -	48·9
B—Area, - - -	70° F. - - -	9·8
Gallery, - - -	73° F. - - -	25·6
C—Near organ, - - -	63° F. - - -	13·6
Area, - - -	68° F. - - -	19·1
Gallery, - - -	65° F. - - -	22·8
D—Near organ, - - -	70° F. - - -	22·7
Area, - - -	70° F. - - -	18·1
Gallery, - - -	75° F. - - -	33·3
Street outside hall, - - -	50° F. - - -	

These theatres I do not specify, as my complaint is not against particular theatres, but of the fact that theatres in general are badly ventilated. Those which I report to you are not worse, probably not so bad, as some others. It will be seen that the pit is pure as compared with other parts. The air rushing in from the stage in part accounts for this. The rising to the upper parts of the house of the heated impure air, is another reason of the nearer approach to purity of the air of the pit. The boxes are much worse than the pit, because they are so enclosed, and have no through current. The air of the amphitheatre is bad, and that of the gallery is exceedingly bad. The temperature of the various parts of these theatres shows what is taking place as to distribution of the air. The boxes were cold as they were not so crowded, and had less of the heat given off from the bodies of occupants.

The pit, in one case, at 70°F. had 18·5 parts of carbonic acid, while in another case with a temperature of 55°F. the carbonic acid present was only 10·8. The gallery, in one case, with a temperature of 61°F. had 26·4 of carbonic acid, while in another case with a temperature of 75°F. the carbonic acid was 32·2. These are conditions of atmosphere which are entirely inexcusable in buildings occupied by the public.

The air of some of the halls of the city also, I have examined. Four examples I place before you. In three of these it will be seen that the air of the area was the best in the halls. In one the air near the organ was the best. In this instance the frequent opening of doors at the platform evidently sufficed to admit air enough to lessen the impurity in that neighbourhood. In all, the air in the gallery was found very bad—in one case 33·3 and in another 48·9 parts of carbonic acid per 10,000 parts of air. This degree of impurity implies extreme inefficiency of the arrangements for ventilation. Such a condition of atmosphere should not be tolerated by the city authorities. The temperature in these halls was high, particularly in those parts in which the carbonic acid was in greatest excess. In one of these halls the temperature in the gallery was 75°F., while the temperature in the street adjoining was 50°F.—a difference of 25°, mainly due to heat given off by skin and lungs. The excess of moisture was very great in the air of the theatres and halls. The effects of this excess of moisture are first to restrict the exhalation of watery vapour by the lungs, and, second, to permeate the clothing with watery vapour, and to restrict the discharge of moisture from the skin. As the water which the skin naturally discharges into the air, so regulating the temperature of the body, cannot be taken up freely by an atmosphere already heavily charged with moisture, the body becomes unduly heated, and perspiration causes skin and clothing to become moist. Sickness or faintness sometimes follows this condition. When the occupants pass from such an atmosphere to the outer air at a temperature 25 degrees lower, the watery vapour condenses, and the skin and clothing become wet. Then the drier outer atmosphere rapidly evaporates this moisture, and in doing so chills the body. A cold or perhaps a pleurisy is contracted. This is blamed on the coldness of the outside atmosphere. It should be charged to the foul atmosphere which has produced unwholesome conditions, and which has for the time, lowered the resisting power of the body. If these

persons had been walking the whole evening in the open air no evil results would have followed.

Churches are frequently as badly ventilated as halls and theatres. The somnolence which so frequently overcomes the hearers is often uncharitably charged against the character of the preaching, when it is really due to the condition of the atmosphere. Sickness and faintness which are so often seen in crowded churches are due to the same cause. Frequently in a church the atmosphere of which becomes hot and foul, a window is opened at the top to let the foul air escape. This is complained of, as causing a draught. The complaint is often well founded, as when there is not also provided a sufficient inlet for air, the open window acts both as outlet and inlet, the cold outer air falling in a stream on the heads of those seated near.

Hospitals require good ventilation more than any other buildings. Some hospitals are well ventilated, many are ventilated indifferently, and some are badly ventilated. One class of hospital, the sanatorium, is ventilated almost perfectly for its special needs.

Having referred to ventilation of buildings as it presently is carried out, we come to the question—How is good ventilation to be secured? In answer to this it may be said that there is no panacea. I wish further to say that I have no system to advocate. Different buildings call for different treatment, according to their circumstances. General principles, however, may be laid down, and the advantages and disadvantages of some of the plans in use may be referred to. In the first place what is required is that the impurities contributed to the air by skin, lungs, and clothing of the occupants, be as speedily and as completely as possible removed, while a sufficiency of pure air is admitted without draught, so as to maintain a reasonable degree of purity. This reasonable degree of purity is not always easy to define. Of carbonic acid 6 parts per 10,000 parts of air is usually stated to be the limit of permissible impurity. For houses it is desirable that this degree of purity should be maintained. In hospitals this degree of impurity should never be exceeded. In schools the same degree of purity should be aimed at, although it may not always be possible to secure it. In workshops perhaps 8 to 10 parts of carbonic acid may be considered the best attainable. In theatres, halls, and churches, 10 parts of carbonic acid should be aimed at as satisfactory, and 12 parts as the limit which should never be exceeded. How is all this to be secured? The first point of

importance is that there should be outlets sufficient for the escape of impure air. These outlets should be so placed that the heated air finds easy exit. The next point is of not less importance—there should be inlets larger in area than the outlets, so that fresh air may enter in sufficient amount, travelling slowly and causing no appreciable draughts. When outlets are provided without proper inlets, either the outlets become also inlets pouring down cold air, or the entering air comes in by chinks, crevices, and narrow openings with great rapidity, causing disagreeable and hurtful draughts. Draughts in apartments large or small are usually due to insufficient inlets. The inlets provided should be well spread over the apartment, so that the incoming air may be well dispersed. A single inlet in an apartment, especially if this inlet be small, is apt to let the air travel straight to the outlet, not really mixing with the air of the apartment. This, which is called short circuiting, renders the attempt at ventilating a failure. If the air admitted be warmed, the inlets may be placed in the lower part of the walls. If the air admitted is cold, the inlets must be placed at a greater height, and as far away as possible from the occupants. For accomplishing these ends many plans are adopted which I do not propose to discuss, but some points in connection with them may be referred to. In buildings in which persons are present in considerable numbers, some motive power must be employed to produce a sufficiently rapid renewal of the atmosphere. In apartments, not crowded, this is not usually necessary.

In single apartment houses, where the chimney acts as the natural outlet some opening should always be provided to admit pure air. Such opening may be made, perhaps, by removal of a brick near the ceiling, should have a grating, and should be always open—the closing of it should be made an offence. Or the window can be made a satisfactory inlet by having it made with an arrangement like Hinckes Bird's, but a fixture, so that there will always be an opening between the lower and upper sashes, directing the incoming air upwards.

In larger houses the window can be made a satisfactory inlet, by Hinckes Bird's method, or by simply lowering the upper sash, a board perhaps being so attached to the upper sash as to direct the air upwards.

In bedrooms the window should be open to some extent during the night in all weather if conditions that are healthy are to be maintained. This is not a matter for the architect. What is

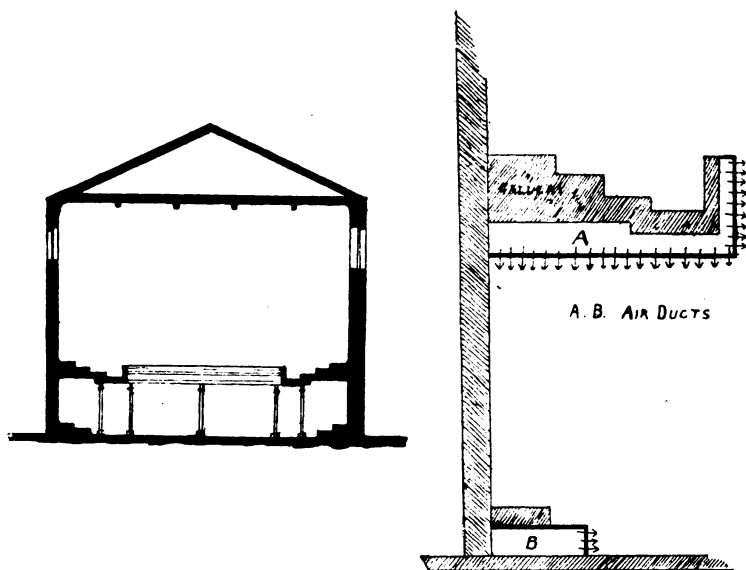
required for this is the education of the people, and the removal of old prejudices.

Workshops require, as a rule, some special arrangements for ventilation. Propulsion and extraction fans, the incoming air being, if necessary, warmed by passing over radiators or hot pipes, will in most cases be satisfactory. Some effective form of ventilation of such places should be insisted upon by the authorities. If this were done much illness would be avoided, and fewer cases of consumption would arise amongst workmen. For schools much the same may be said. It is specially important that these be well ventilated.

Halls, churches, and theatres which are intermittently occupied, which are crowded, and which have a small cubic air space per person, require very special treatment. The present condition of these buildings as to ventilation is as a rule intolerably bad. The problem of ventilation for such buildings is by no means an easy one, but it is a problem which must be faced and must be solved. The large amount of fresh air to be admitted must be made to travel so slowly as not to cause a draught. This implies that openings should be very numerous, very wide spread, and that the total area of the openings should be large in proportion to the amount of air to be admitted. These are primary conditions. The extraction may be effected by heated flues in the ceiling, but if this plan is adopted, the flues must be large and numerous. Fans may be used for extracting, and if well placed, and aided in their work by sufficient inlets they work very well. For supplying fresh air many plans may be adopted. The plenum system may be adopted, the air being admitted not at the ceiling, but at a height a little over the heads of the occupants. This will require, however, a large number of openings well spread. In the wall under the galleries long, perhaps continuous, gratings, admitting the air in fine streams, not in thick jets, will serve to diffuse the admitted air through the halls. If the extracting fans or flues are sufficiently powerful, and the openings sufficiently large in the mass, no propulsion of admitted air may be called for. But probably for halls and such buildings it may be necessary to combine mechanical extraction with mechanical propulsion to secure the circulation of the necessary amount of air.

The problem, as has been said, is not an easy one. To take an instance, let us consider the requirements of one of the halls already referred to.

This hall is seated for about 2800 persons, and when crowded, with many standing, it holds 3500. The air space of this hall is 274,000 cubic feet. This provides for a seated audience 100 cubic feet of air, and for a crowded audience 80 cubic feet per head. That is to say that from floor to ceiling each person has the cubic air space just mentioned. To maintain an atmosphere containing not more than 6 parts of carbonic acid per 10,000, which is recognised as the limit of permissible impurity, over 10,000,000 cubic feet of air would require to be admitted per hour while a similar amount escaped. This is what would require to be done for the crowded hall. It may be admitted that



the purity aimed at may be unattainable. Let us assume, therefore, that 10 parts of carbonic acid may be considered a more reasonable limit—and it may be said that anything beyond this is decidedly hurtful to health.

With 3500 persons present the amount of air to be admitted so as to maintain an atmosphere with not more than 10 parts of carbonic acid, would be $3\frac{1}{2}$ million cubic feet. That is to say the atmosphere of the hall would require to be changed twelve times per hour to maintain this moderate degree of purity. To admit so large an amount of air requires the employment of power under thorough control. It requires that the air be well and equally

warmed to avoid producing chill. It implies widely-spread openings admitting the air slowly—at less than three feet per second. To admit $3\frac{1}{2}$ million cubic feet per hour, the air travelling at the rate of, say, three feet per second, would require inlets having a total area of over 300 square feet (324). This area of inlet is very large, as compared with what is usually provided, but a less area will not admit the amount of air necessary to secure the very moderate degree of purity aimed at. How this can best be done is for architects and engineers to determine. But a large portion if not all of this inlet area, might be provided by a freely perforated air space (A) under the ceiling which lies beneath the galleries, or in the front of the gallery, with smaller openings (B) near the floor. If the air were well warmed it would pass rapidly upwards through the hall and would occasion no sense of draught on those sitting under the galleries, especially if its upward progress were sufficiently aided by powerful extraction at the ceiling. This suggestion I make not as a tried experiment, but as an idea to be considered by those practically engaged in such undertakings.

What has been said of halls, applies equally to churches, theatres, music halls, and other such buildings. The necessity for better ventilation is obtrusively evident. The means to secure it must be sought and found by those who design such buildings.

Hospitals require special consideration. These are not, as a rule, crowded buildings. They differ from schools, halls, etc., in being continuously, not intermittently, occupied. The same persons are living in them night and day. These persons are unhealthy, and the emanations from them are more hurtful than those from healthy persons. The inmates are weakly, more or less, and have a more urgent need of pure air than persons in health. The air of hospital wards must be kept with the minimum amount of impurity. Given a sufficient air space, such as is provided in all modern hospitals, the task seems an easy one. The air of course must be warmed in cold weather. It must be freed from dust by some form of screening. It may be necessary to moisten the air, as heating lowers the relative humidity. Many plans of ventilation are in use in hospitals. Extraction and propulsion fans are employed. Heated flues extract air, while fresh air is admitted near the floor under radiators. These systems are found to work well. The windows of all wards should be made to open in sections, and be so arranged that the air can be directed upwards. The plenum system has been tried in many hospitals.

In theory this system seems nearly perfect. In schools it has been found satisfactory on the whole. But as to its suitability for use in hospitals grave doubt exists, and in private houses it has not been found to produce satisfactory conditions. This system succeeds in driving in large quantities of washed, screened, moistened, and warmed air. It can be regulated with considerable precision. The air which is driven in, so manipulated, and passed through long, dark tubes, usually more or less dusty, seems to have its vitalising powers reduced. Patients and nurses living in this atmosphere complain of languor, and tend to become feeble and anæmic. The patients do not progress so well as in a ward ventilated by open windows, or by other measures which secure the direct admission of outside air. In wards ventilated on the plenum system it is very common to find that windows are opened by nurses and house surgeons who complain that without this they suffer from the want of air. In one hospital in London which I visited in connection with this matter, I found that in the dispensary where patients are examined, the surgeons regularly opened the windows. The Master of Works, to prevent this, fixed the windows by inserting screw nails. He complained to me that the surgeons brought screw drivers and removed the nails. The surgeons must have been seriously impressed as to the want of pure air, in an apartment ventilated on the plenum system, to take such trouble. In one hospital ventilated on the plenum system, on entering the children's wards I was surprised to find the windows widely open. This was done by order of the physician in attendance, and was done so constantly that the connection with the plenum system was cut off. In other hospitals ventilated on the same system I found the windows open, and I found that the apartments occupied by the resident surgeon had been by him cut off from connection with the plenum system. Much the same experience has been found in many private houses similarly ventilated. The inmates complain of a feeling of languor and listlessness, and tend to become anæmic.

The plenum system seems to work well in buildings occupied intermittently by comparatively large numbers, as in schools. But it does not seem to be satisfactory in buildings which the inmates occupy night and day.

One may seek to find some explanation of this. A complete or satisfying explanation has not yet been supplied. Air which has been breathed, may have its carbonic acid removed by washing

with caustic potash; it may have oxygen added to make up its normal proportion. Chemical analysis may pronounce this air pure. But it is found by experiment that animals do not thrive in this atmosphere. They sicken and die. Passing an electric spark through this atmosphere, to some extent restores its vitalising power. There is in pure air a something which we do not yet know which has an important influence on vital processes. It may be some chemical substance—although this is improbable. A few years ago it was assumed that the chemistry of air was fully understood. The discovery of argon, krypton, and other unsuspected gases in the air greatly surprised the chemical world. Little is as yet known as to the electrical condition of the air, and less as to the rays such as Hertizian rays, X rays, Becquerel rays, and others in relation to air and to vital processes. The physical changes produced in air by sunlight are imperfectly understood. It may be that some rays probably of very short wave length present in the open-air, and giving to this the character which is best described by the Scotch word “caller,” are destroyed by the passage of air through screens and dark tunnels. Consumptives frequently improve when transferred from a room with windows removed, in which the air seems at its purest, to the open-air, away from walls. The outside air has more vitalising power than even the best air of any room. The physical and chemical explanations are awaiting. The physiological evidence is conclusive.

Whatever the explanation may be, the lesson which we learn is that the air should be brought into buildings as directly as possible from the outside, with the minimum of treatment.

Last century the lesson of the necessity for pure water supply was learned slowly, mainly at the expense of epidemics of cholera. During the early part of this century it is to be hoped the lesson of the necessity of a pure air supply in occupied buildings will be learned. Consumption and its treatment show that while impure air renders the human system a suitable soil for consumption, pure air so invigorates the system that the consumptive is enabled to overcome the disease. The habitual breathing of pure air tends to greater vitality, and, therefore, to the more successful resistance of the system to the influences producing disease.

The public must learn the value of pure air and the danger of impure air. People must learn to enjoy pure air, and to admit it with freedom to their houses. Civic corporations should

endeavour to secure a purer air of their cities by dealing more vigorously with smoke and chemical pollution. They should also deal with ventilation of all buildings occupied by large masses of people, such as halls, theatres, and churches, and with workshops and factories.

The architect, the engineer, and the builder have a large and responsible task before them in this connection. They can, however, only go so far as their clients are educated enough in the matter to permit them. Yet it is to these gentlemen that we must look for improvement in this matter. I have sought to point out the necessity. It is for them to devise means, and to seek to induce their clients to adopt them.

Notes on certain parasitic protozoa from the groups of the Myxosporidia and Hæmosporidia. By MURIEL ROBERTSON, M.A., Carnegie Research Scholar.

[Read before the Biological Section, 24th February, 1906.]

THESE notes deal with parasitic protozoa belonging to the groups Hæmosporidia and Myxosporidia which I have lately had the opportunity of collecting. They are of a preliminary character as the forms dealt with are still under investigation.

Trypanosoma pythonis, n.sp.—This Hæmosporidian is parasitic in the blood of an African Python from the Gambia. I have through the courtesy of Dr Logan Taylor had the opportunity of looking through some films made from the blood of an infected animal, and I am indebted to him for the permission to publish the results.

The parasite in question is a fairly large organism, measuring 11-16 μ , it is slightly pointed at one end, and there is a tendency to curl up at this end, but this does not approach the bent up double-shanked condition of Hæmogregarines. The infection was evidently a severe one, about 70% of the corpuscles were attacked, two and even three parasites were to be seen in one erythrocyte. The protoplasm is finely alveolar, and no conspicuous granules, food particles, or pigment are present, vacuoles are also absent. (Figs. 1-3.) As in many blood parasites there is no obvious differentiation into ectoplasm and endoplasm. Quite the most conspicuous feature of the organism is the nucleus, which is large for a protozoon of this size. At first sight it strongly suggests the complex reticulate character of a metazoan nucleus, more especially as it is often rather elongated, this tends to mask its true nature. In favourable specimens, however, it appears to be of that type so often found in flagellates, and more particularly in blood parasites. In fact it closely resembles the nucleus described by Schaudinn in *Trypanosoma noctuæ*, that is to say it is composed of a hollow sphere showing eight masses of chromatin, within this sphere is the karyosome, which is also certainly at times a hollow structure showing a number of thickenings. I have on several occasions made out 8 of these, but the

different masses of chromatin are only rarely clearly defined in the karyosome. The whole nucleus appears to be bounded at this stage by that for Protozoa rather doubtful organ the nuclear membrane. Next to be described is the centrosome, or as it may, I think, here be called, the blepharoplast. This appears as a small but still well defined granule, and is to be seen in the vast majority though not in all of the parasites; indeed, it is a very constant feature.

The position of the blepharoplast in relation to the nucleus varies in rather an interesting and suggestive way. Thus in what I take to be one of the earlier stages it is lying closely apposed to the large nucleus (Fig. 1), in a later stage the blepharoplast is more removed but is bound to the big nucleus by a quite definite thread (Fig. 2); this thread seems ultimately to disappear. This centrosome body is not an altogether simple granule, when once it has left the near neighbourhood of the large nucleus it becomes clear that rays pass from it into the cytoplasm. I am unable at present to say anything as to their meaning. The centrosome or blepharoplast seems capable of increasing in size and of division, the products showing a strong tendency to remain connected together by a staining fibril (Fig. 3). This process of division may be repeated, and rather complex appearances are found but, owing to the limitations of the material, I am not in a position to give a definite interpretation of the facts observed.

There is a point of interest that I have not been able to determine yet, namely, the actual mode of origin of the blepharoplast. It undoubtedly is a product of the large nucleus, but I cannot definitely say that it arises from it by heteropolar mitosis. The evidence, however, is rather in favour of this supposition, in which case the thread joining the blepharoplast to the large nucleus would correspond to the spindle formed by the central granule which in Schaudinn's description lies within the karyosome. As far as I can at present see the small nucleus or blepharoplast does divide by mitosis, but the details are a little obscure. The phenomena just described strongly recall Schaudinn's account of the preparation of the flagellar apparatus in *Trypanosoma noctuae*. This account is now too well known to require recapitulation here.

It is true that I have not yet found any actual flagellar forms, which, however, does not greatly surprise me, as their absence can be explained in a number of ways. The material to begin with is

very limited, and composed, as far as I am aware, only of peripheral blood; the flagellate forms may possibly be found in the deep-seated organs, such as the liver or spleen, or what is much more likely, may only finally be developed in another host.

In the light of Schaudinn's researches on the life history of *Trypanosoma noctuae* it is pretty clear that the parasite in question is really the intracorpuseular stage of a *Trypanosoma*, and I propose to call it provisionally *Trypanosoma pythons*. This research is naturally of an incomplete nature, as blood taken on a single occasion from an infected animal rarely gives a sufficient number of different stages to form anything like a complete series of the changes undergone by the parasite during its sojourn in the blood. This criticism is more particularly applicable to the parasite here described, which very probably completes its life cycle in another host.

The remaining forms that I propose to mention were found in various fishes which I investigated at the Millport Biological Station early in January, 1906. The parasites found were Myxosporidia and Hæmosporidia.

Chloromyxum leydigi, Ming. parasitic in the gall bladder of elasmobranchs was met with in one out of two large dogfish (*Scyllium*) examined. The trophozoite is very large, with pointed transparent pseudopodia. The protoplasm is filled with globules, usually yellow, according to various authorities, but in the specimens I observed they were of a beautiful pale sage green, the spores were of the sculptured cockleshell shape typical of the species—these spores have four polar capsules, and at the opposite end a tuft of short tails.

Leptotheca agilis Thél. was found in the gall bladder of a common flounder (*Pleuronectes flesus*) this parasite has so far been noted only in the whip-ray Trygon and in Scorpaena, two fishes which are from such divergent groups that the parasite has, I expect, like so many Myxosporidia, a rather wide range of hosts. The trophozoite here is small and never contains more than two spores, the pseudopodia are pointed and much longer than is usual with members of this group.

Myxidium sp. (?). The third of these Myxosporidia was found in the gall bladder of the saithe (*Gadus virens*). The infection appears to be very common, practically every fish is affected, freshly caught specimens as much as those living in the tanks. Lythe (*Gadus pollachius*) from the same tanks were not infected.

I have not been able to identify the species of this parasite quite satisfactorily ; it is, however, evidently a Myxidium. The spore has two polar capsules at opposite ends, and corresponds very much in appearance with the spore of *Myxidium incurvatum* Thél., but the trophozoite does not correspond as it is larger and polysporous.

Hæmosporidial forms met with were found in Pleuronectids—*Pleuronectes platessa* and *Pleuronectes flesus*. They consisted of a large Trypanosome and a Halteridium-like parasite inhabiting the red blood corpuscles, a point of interest being that they were found associated in the same host.

The Trypanosome, which is very scarce in the blood, is a large creature measuring from 50 to 60 μ in length : it has a narrow undulating membrane produced at one end into a flagellum (Figs. 4 and 5). The movement of this animal is particularly beautiful ; it sometimes proceeds forwards with a graceful eel-like motion, at other times rolling itself up into a wheel and whirling round in a circle.

I am as yet in ignorance of the details of the nuclear apparatus of this creature, as, like all Trypanosomes, it is difficult to stain in an altogether satisfactory way. There is, however, a large nucleus lying in some cases slightly anteriorly to the centre of the creature, that is to say, it is nearer to the flagellar end ; there is a complicated blepharoplast present which takes on a brilliant red colour when stained with polychrome methylene blue. This blepharoplast varies in position, but is always near the vacuole which lies a little in front of the often truncated posterior end of animal. The blepharoplast may form a single compact body, or may be composed of several separate elements.

A number of well marked striations are to be seen passing longitudinally along the body : these are very conspicuous in individuals stained with polychrome methylene blue or thionin, but are difficult to see in Giemsa preparations.

A feature rather unusual is to be noted in most specimens, namely a varying number of vacuoles in front of the one normally present. Division and further stages of the life history have not as yet been observed.

I propose to follow the method of classification of Trypanosomes suggested by Laveran and Mesnil, and call this form *Trypanosoma pleuronectidum*, n.sp.

The Halteridium is a small creature measuring 7 to 12 μ . There is a fair sized nucleus of much the same type as that

described for the parasite in the Python, only the karyosome is a more compact body and does not appear ring-shaped in the ordinary resting stage. It is a more variable organ, and the appearance it presents in the different specimens suggests that it is an important element in the nuclear apparatus. The number of chromosomes is not quite easy to make out, but I have counted the number eight in what appears to be the typically resting state. The nuclear membrane is not at all a constant structure. It appears to be present in some stages, but very frequently the chromatin lies arranged in definite little masses without the faintest sign of a surrounding membrane.

A centrosome is not present as a constant feature in the majority of specimens, but a well marked granule, whose appearance and staining reaction strongly suggests a centrosome, is to be seen in a large number of cases. I am not as yet clear as to its origin. It very usually lies just internal to the vacuole which almost invariably occupies the one end of the creature. This end is often slightly broader than the opposite non-vacuolated extremity. This vacuole is a very constant feature, and is always in the same position.¹ (Figs. 6 and 8).

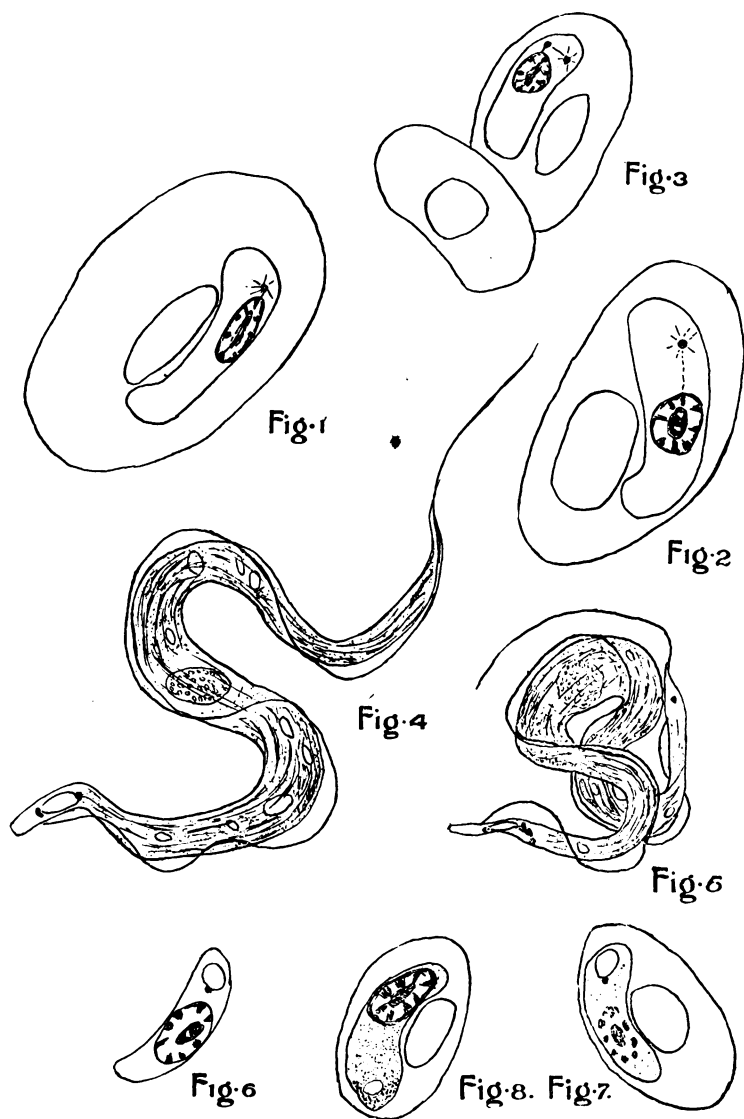
The size and appearance of the parasite show some variation; the usual form is rather slim, with finely alveolar protoplasm, and few, if any, granules, but forms are to be met with which are of markedly larger dimensions, both broader and longer, and with a more granular protoplasm. The nucleus of this form is very large and has a more scattered and irregular appearance; the vacuole is sometimes missing. Possibly this is a macrogamete.

I do not wish to name this form at present, as it is impossible to place parasites of this nature without a fuller knowledge of their life history than I have as yet at my command.

The occurrence of these parasites is as follows:—Out of ten plaice examined four were infected with the Halteridium-like endocorpuscular form, two of these infected animals also showed the large Trypanosome. Out of eight flounders examined one showed infection with the endocorpuscular parasite, and one with the Trypanosome. Unfortunately the films made from this last specimen were very badly fixed, and I cannot make certain as to the presence of the endocorpuscular parasite.

¹ It appears that this structure is not a vacuole but corresponds with the eosinophile body described by Dr Rogers in the "*Hepatomonas*" (no doubt a misreading of *Herpetomonas*), which causes the disease of kala-azar.

PLATE I.



PARASITIC PROTOZOA.

I do not wish at the present time to assert that the endo-corpuscular form has anything to do with the Trypanosome. It may very possibly be a case of double infection. However, it is interesting to find the two forms in the same host. The plaice and flounder appear to be new hosts for Trypanosoma. Laveran and Mesnil put them into the list of fishes where the parasite is not found. This Trypanosoma, moreover, appears to differ from the form observed by these authors in the sole, where it is interesting to note they also found a Hæmogregarine of the typical doubled up type.

The work was done in the Zoological Laboratory of the University of Glasgow, under the direction of Prof. Graham Kerr.

EXPLANATION OF PLATE.

All the figures, with the exception of Fig. 3, were drawn with the Abbe camera lucida under the 2 mm. oil immersion lens (Zeiss) and the 18 eyepiece, the drawing being on the table. Fig. 3 was drawn under the 3 mm. imm. lens and 18 eyepiece.

- Fig. 1. *Trypanosoma pythonis*, n.sp., showing blepharoplast close to nucleus.
- Fig. 2. *Trypanosoma pythonis*, showing blepharoplast remote from nucleus. This is the position most usually seen.
- Fig. 3. *Trypanosoma pythonis*, blepharoplast divided into two, and joined by fine fibril.
- Fig. 4. *Trypanosoma pleuronectidum*, n.sp., showing nucleus, blepharoplast, and vacuoles.
- Fig. 5. *Trypanosoma pleuronectidum*, n.sp.
- Fig. 6. Parasite in erythrocyte of plaice, showing nucleus (the membrane is absent), vacuole and centrosome.
- Fig. 7. Parasite of plaice. This individual happened to be free in the plasma, nucleus with membrane, vacuole and centrosome to be seen.
- Fig. 8. Parasite of plaice, large granular form, possibly a macrogamete, large nucleus and vacuole present, centrosome apparently absent.

Social Derelicts; or the Contribution of the Army to Human Wastage.

By JOHN S. SAMUEL, J.P., F.R.S.E.

[Read before the Society, 25th April, 1906.]

ONE of the last acts of the Secretary for War under the late Government was to appoint a committee, of seven gentlemen, to inquire into the question of civil employment for discharged soldiers. Among others that Committee includes Sir Edward Ward, Permanent Under-Secretary for War; Major General Lord Cheylesmore, and Sir Frederick Harrison, General Manager of the London and North Western Railway Company.

The matter, while a pressing one, is not new, nor is this the first Committee that has been formed to consider it. A Select Committee of the House of Commons was appointed for the same purpose in 1877, and another in 1895. But, unfortunately, the investigations of these Committees have not resulted in a solution of the problem, and it is now more acute than ever.

Roughly stated, the problem, as it presents itself to-day, and as the result of the short-service system, (recently partially abolished), is this, that the labour market is yearly flooded with young men who have entered the army at from eighteen to twenty years of age, and are discharged at the end of their term of service, having learned little or nothing in the Army, and having, perhaps, entirely forgotten any trade they may have partially acquired before enlisting. Nearly all of them, on leaving the Army, enter themselves at the various employment bureaux as "labourers," and, as in the present position of trade, there is little or no work for such unskilled labour, they degenerate, in a very short time, into loafers, beggars, or worse. Of the men discharged during, and immediately after, the late war, a very large number are simply tramping about the country—sort of twentieth century "sturdy beggars."

I was prompted to give some consideration to the matter dealt with in this paper, in my capacity of Honorary Secretary for Glasgow of the Soldiers and Sailors Help Society—an organisation which was brought into existence in 1899 owing to the distress occasioned by the South African War. A branch of this Society

was inaugurated in Glasgow, at the request of the President, Her Royal Highness the Princess Christian, and the extent of the work which has devolved upon it here will be appreciated when I say that, during the past three years, I have passed through my hands no fewer than 910 ex-soldiers. I have personally seen and interviewed all these men, inquired into their circumstances, examined their Army papers, ascertained their qualifications, and furnished them with a recommendation to employers of labour in the city who might assist them in getting work. I have come into contact with men from every branch of the Army, and have therefore some knowledge of the conditions of service, and how these operate in the direction of qualifying or otherwise, for efficient civilian employment. The other branches of the Society all over the country deal with proportionately large numbers of men, and during 1904 the Society, as a whole, assisted no fewer than 20,272 ex-soldiers. The returns for 1905 are not yet available.

The most of the men who come under the Society's notice are soldiers who have only served the minimum three years, and who enlisted under the Regulation which three or four years ago introduced that short period service, but which was recently partially superseded, so far as infantry regiments are concerned. In what I may say hereafter I am largely referring to young men who took advantage of this short period of service, and who left the Army at its conclusion. My observations, however, equally apply to the case of soldiers who leave the Army after periods ranging from three to twelve years, and who prefer taking their discharge to completing twenty-one years' service.

I have been impressed with the enormous responsibility which the Army authorities are placing upon the country by discharging from the ranks year by year, large numbers of short service soldiers, with no trade at their finger ends, and who simply go to augment the class of uninstructed and unskilled labourers. It is calculated that during this present year (1906) no less than 38,000 men will leave the infantry on discharge or transfer to the reserve, and that next year the number will be as high as 42,000. These figures will show the gravity of the situation with which we are confronted. The supply of unskilled labour, from ordinary civilian sources, far exceeds the demand, and yet, this is the only class of employment for which the large majority of discharged soldiers are fitted.

Let us look at the question of Army recruiting and discharge as
VOL. XXXVII. F

it existed before the partial abrogation of the Regulation permitting a three years' service, and as it largely exists still. There are two classes of men who enlist, viz. (1) the respectable young man who is quietly and industriously working at some useful trade, and is in process of becoming an efficient and qualified artisan, and (2) the youth who has no settled employment, is frequently idle, and who, in a condition of poverty and distress, goes to the recruiting office, to seek, in the Army, a temporary refuge from all his ills. I shall refer to this latter class later on, but meantime direct your attention to the young man who is attracted to the Army for its own sake. The glamour of the service appeals to him, and the scruples which prudence suggests are quieted by the reflection that he can enlist for a period of three years, and that thereafter he may return to civil life as a reservist, with an allowance of sixpence per day for nine years. The attractions for the time are irresistible, and he lays down his tools to accept the King's shilling. For the next three years he is being drilled, and in time becomes an efficient unit of the line. He is just acquiring a value as a soldier when his time expires, he declines to extend it, and returns to civil life as a reservist. The Army has had all the trouble and expense of training and equipping him for the profession of arms, and no sooner is this work accomplished than the individual slips from their control and returns to his former sphere.

It is estimated that between 14,000 and 15,000 three years' men left the Army during the twelve months ending 30th September, 1905, and the percentage of the same class who extended their service during that period was thirty-six.

I have been pained to notice among the ex-soldiers who have passed through my hands, the gradual process of decadence and degeneracy which has resulted through the heart-breaking experience which many of them have had, of hopeless and unsuccessful efforts to get employment—young men who left the Army full of hope and vigour, and anxious to take their place among their fellows, discharging some useful duty, in an agreeable sphere, but who have no sooner bade farewell to the barracks than they find that they have been left behind in the march of commercial and industrial progress. While they were being drilled and instructed, and fitted to protect home and Empire, their former fellow workers had been forging ahead, and now, too late, they find themselves laggards in the race, for the place they once occupied knows them no more. If they elect to return to their trade, they must begin

at the point where they left off, with no commensurate advantage for the loss of the intervening years. It is little wonder that so many seek employment where they may, and drift along the precarious path of fitful and casual employment—the *prestige* and *morale* resulting from their army training soon disappears, and the trig, smart, well-set-up soldier, whom all admired, as he swung along in his brilliant and well-fitting uniform, degenerates into the haggard and starved civilian.

In a recent correspondence in the *London Times*, Lord Monks-well referred to the helplessness of the soldier who is too often turned out into civil life with stiffened limbs and vacant brain. The opinion of those who come into contact with applicants for relief is, that the soldier is a feeble combatant in the battle of life, and this, not by his own fault, but because he is not given a fair chance. He is taken away from civil life exactly at that period when he might otherwise be learning what would be most useful to him as a mechanic, as a craftsman, or other civil vocation. He thus loses many opportunities for establishing connections and interest. The soldier has very few opportunities of learning any new kind of work, or of keeping himself practised in what he may have been taught before joining. Every day our Society has to deal with men who, before enlisting, were plumbers, tinsmiths, moulders, and so on, and who confess their utter inability to take up again their craft.

In a return presented to Parliament on 1st August, 1898, some suggestive statistics are given as to the extent to which ex-soldiers were chargeable on the poor rates of England, Scotland, and Ireland, in the month of December, 1897, as inmates of work-houses, and recipients of outdoor relief. Without wearying you with details of the returns, I may point out that no fewer than 11,093 discharged soldiers were in the work-houses or casual wards, or received out-door relief from the Unions of the United Kingdom on 20th December, 1897. These were not, by any means, all old men, but included men from 20 years of age and upwards. We must bear in mind also that that return applied to a period anterior to the introduction of the short service enlistment system.

Through the courtesy of the Clerk to the Glasgow Parish Council, I am able to give a return of the number of discharged soldiers who applied for relief to that parish for three years ending 15th May, 1905. It shows that a total of 347 applied for relief,

of whom 83 were between 20 and 30 years of age ; 155 between 30 and 40 ; and 109 over 40 years of age. 243 were single, 74 married, and 30 widowers. 81 had served less than three years in the army, 96 less than six, 110 less than twelve, 29 less than twenty, and 31 over twenty years. Their chargeability to the parish is described as follows :—Old age, 27 ; illness, 81 ; drink, 205 ; immorality, 15 ; improvidence, 8 ; insanity, 9 ; while 2 were able-bodied. Only 44 out of the 347 were tradesmen. Of the admissions to a work house in London, during twelve months, from 15 to 20 per cent. were those of ex-soldiers.

As to the extent to which ex-soldiers become vagrants, I may here cite the experience of the Chief Constable of Wiltshire, who causes a census of vagrants to be taken once a quarter in his county, and he finds that on an average about 16 per night of those relieved have been in the Army. He reports that out of 44,038 vagrants relieved in the county during 1905, 5,737 had served in the Army, 495 in the Navy, and 209 were still in the army reserve (or a total of 6,441, ex-soldiers and sailors). For 1904 the figures were 4,842 men who had served in the Army, 436 in the Navy, and 101 still in the Army Reserve (or a total of 5,379 ex-soldiers and sailors). These figures speak for themselves, and I have no doubt they may be regarded as typical with reference to the other districts throughout the country.

The experience of Labour Homes and Refuges of all descriptions is the same, viz.:—That a considerable proportion of those whom they assist are ex-soldiers. The records of the Newport Market Refuge, London—a typical institute—show that for the last three years considerably over 50 per cent. of the applicants for food and shelter were discharged soldiers, mostly of the unskilled labouring class.

I am aware that, in considering this question of the employment of discharged soldiers, one must not forget the many agencies that exist for their assistance. I am acquainted with the work accomplished by the National Association for the employment of reserve and discharged soldiers. The Glasgow branch, which, until recently, was under the able charge of my friend Captain Finlayson, and is now in the no less capable hands of Major Masterson, V.C., deals with about 900 men per annum. I have already stated how many men have come under my notice in connection with the work of the Soldiers and Sailors Help Society, and it would be unpardonable, on my part, did I omit to

acknowledge here, the great assistance which employers of labour render in the direction of assisting discharged soldiers, to obtain work. In Glasgow, these employers are always willing to give employment to discharged soldiers, provided the men presenting themselves are qualified. The following statistics will show the extent to which public departments and railway companies have recognised the claims of ex-soldiers :—

CORPORATION OF GLASGOW—

The Tramways Department employs about	400 or 500
The Police Force, - - - - -	138
The Gas Department, - - - - -	124
The Cleansing Department, - - - - -	75
The Water Department, - - - - -	40
The Electricity Department, - - - - -	37
The Statute Labour Department, - - - - -	26
The Parks Department, - - - - -	12
	842

RAILWAY COMPANIES—

The North British Railway employs - - -	571
The Caledonian Railway employs - - -	417
The Glasgow & South Western Railway employs	160
	1148

The Glasgow General Post Office have 152 ex-soldiers on their staff as postmen and assistant postmen, and last year 80 were added, in accordance with an unofficial arrangement arrived at between the Postmaster General and the Secretary for War, by which one half of the vacancies in the classes of town postmen and assistant town postmen are reserved for ex-army and ex-navy men of good character.

This aspect of the question suggests the view that the Government might, with advantage, open more avenues of industry for ex-soldiers in the various departments of the public service. At present no department of the public service is compelled to employ ex-soldiers.

This is all the more extraordinary in view of the recommenda-

tions of the Select Committees of 1877 and 1895. The former, of which the Right Honourable Mr. Childers was chairman, was appointed to enquire how far it is practicable that soldiers, sailors, and marines who have meritoriously served their country should be employed in such Civil Departments of the public service as they may be found fitted for.

That Committee recommended that the appointments of permanent messengers for which "soldiers and sailors appear especially suited" should for the future "be exclusively made from persons who have served;" and also that with reference to civil appointments made under the system of open competition, and for which soldiers and sailors are deemed suited, great care should be taken so to adjust the conditions of examination as to give fair weight to those branches of knowledge in which their training has especially enabled them to make progress.

The Select Committee of 1895, of which the late Sir George Chesney, Viscount Wolmer and Mr. Brookfield were successively chairmen, reported that while nearly 18 years had elapsed since the former Committee reported it did not appear to them that the results had been on the whole commensurate with the necessities of the case, and that although occasional attempts had been made to carry out the spirit rather than the letter of the recommendations of the 1876-77 Committee, the State had not yet adopted any sufficient and continuous policy for the employment of reserve and discharged soldiers, the most important movement in that direction having been the result of private enterprise.

In this connection the following sentence in the Annual Report for 1904 of the Soldiers and Sailors Help Society is significant, viz, "Your Committee noted, with regret, in the Report of the Director of Recruiting and Organisation the statement that practically no employment had been received by ex-soldiers during the year, in Government Offices exclusive of the War Office, as they are of opinion that men who have given up the best part of their lives to the service of their country, should be given the preference in appointments of this nature."

A suggestion has also been made that Government contracts might contain a stipulation that a certain number of ex-soldiers should be employed in connection with them. This would, however, be a course of doubtful expediency as it would displace free labour to some extent and only create unemployment in other directions.

In addition to the Societies already mentioned I am aware of the existence of other agencies through whose instrumentality much assistance is rendered to ex-soldiers. The Corps of Commissionaires does excellent work among a limited class of ex-soldiers, and the members of it are a credit to that admirable organisation. The corps is recruited from the picked men of the various branches of His Majesty's Naval and Military Service, and is composed of men who have probably served longer than the minimum period in the Army or Navy, so that it does not really apply to the class of men with whom I am at present dealing. The Salvation Army, the Charity Organisation Society, and the various Church Army Labour Homes, are also entitled to all praise for the manner in which they assist soldiers who have become stranded to be refloated in life.

But, after all, employers get little encouragement to continue their interest in ex-soldiers, and their patriotic action in this direction is oftentimes ill-requited, for there is no doubt the Army, in times of peace, does little for many men, but create and foster a distaste for honest and sustained labour. The young short service linesman, for example, coming, say, from a "hive" regiment—except for the routine of his daily drills, and whatever "fatigues" he has to do, has been accustomed to spend his leisure more or less aimlessly, has indeed been more or less "on the loaf," and even if he gets work, when he leaves the colours, he is apt to tire of it soon. As Secretary of the Soldiers and Sailors Help Society I am daily meeting with men who have been tradesmen, but who have no desire to return to their trade, but who are looking for something "light." The impression I have formed that the Army does much to inculcate habits of indolence and unrest, has been strengthened by the numerous instances in which, when work was found for, or offered to, an ex-soldier, he either declined to take it, or after having worked for a short time, disgraced his recommendation by his incompetency and laziness. Indeed, there is one case before my mind at the present moment of an ex-soldier discharged with a very good character, who was twice offered a good situation, but who disappointed his patrons by not turning up, preferring rather to extract money from the benevolently inclined on the strength of the Society's recommendation. It is experiences such as these that have helped to generate among some employers of labour a prejudice against ex-soldiers, for even when they get work they do not justify the opportunities afforded

to them. The following two letters from large industrial firms speak for themselves :—

“DEAR SIR,

Re D.B. and S.I.

The two men above-named have been employed by us for about a fortnight. They had the usual holiday last week with the remainder of our workmen, starting work again at 9 a.m. on Tuesday morning. At noon they both asked to be allowed to go home as they felt tired. They were told they could not be allowed to go. Thereupon they asked for their discharge which was given them. We thought it best to inform you of this matter, because such occurrences give all men a bad name who have been similarly recommended.”

Again, in answering a request for employment, made by the Society on behalf of some men, the following reply, from another firm, was received :—

“DEAR SIR,

We regret that we have no opening at present. But we wish to say that of the five or six men whom we started here on your recommendation, not one turned out satisfactorily.”

These cases are not exceptional, and lead me to say that, while no doubt a number of men are attracted, as I have mentioned, to the Army by the glamour of the service and leave situations to join the colours, there are a great number who come under the second class, to which I have already alluded, viz.:—those who go to the Army as a make-shift, because they are out of work, as a remedy, in short, against destitution. They return after their limited period of service is over, little, if anything, the better of their sojourn in the ranks, but invested with all the *prestige* of their Army connection, upon which they trade when soliciting assistance of any kind. Their Army discipline has done nothing to make them more reputable than they were before. Indeed their last condition is often worse than the first.

The consensus of opinion is, that ex-soldiers, under present conditions, and with few exceptions, are not fitted for any employment demanding initiative and resource. They make ideal watchmen or porters, and may be relied on in positions where they receive explicit and definite instructions as to their duties. Their Army discipline would enable them to perform these duties with mechanical regularity and undeviating precision, in other words, as automata ; but if any emergency arises calling for instant and individual action, they are helpless.

After all, it seems to me, the difficulty of getting situations for ex-soldiers would be considerably lessened were they fitted for a greater range of employment when in the Army. As Mr Edgar Wallace, the war correspondent for the *Daily Mail*, said some time ago, what the Army requires is some profitable method of employing its spare time, so as to fit the men for the competition in civilian life. Mr Wallace speaks with knowledge, for he was himself in the ranks for six years, and was Reuter's correspondent during the South African War.

Lord Monkswell, and others have frequently called attention to this subject and to the vital importance of endeavouring to fit the soldier for civil life while he is with the colours, and this was strongly insisted upon at a conference of officers held in Aldershot in 1889. Hardly anything has, however, been done, with the exception of a permissive power having been inserted in the King's Regulations to establish workshops whenever practicable. I do not know whether commanding officers are averse from any scheme of civil training for soldiers. It is asserted, however, that they are. And, of course, it is natural enough for commanding officers to say that their business is to make soldiers and not joiners or shoemakers. But soldiers, *qua* soldiers, are of no use in the labour market. Indeed this was recognised by the Select Committee of the House of Commons, of 1895, already referred to, which considered the question of employment of discharged soldiers, when it declared that the only sound basis of voluntary service is to treat the soldier as much like a civilian as military exigencies will permit, and above all, to cultivate and not to starve his intelligence. On these lines, and on these lines only, would it be possible to deal adequately with the problem of employment for discharged soldiers, and to make sure of maintaining under the voluntary system, an Army large enough and efficient enough for all the needs of the Empire. Speaking recently in Edinburgh, General Leach, commanding the forces in Scotland, expressed the same view. He said, that the Government should be urged to carry out the promise they made several years ago of establishing in every battalion and in every unit workshops in which the men could be taught some trade during their service with the colours. Some years ago, he said, he had the opportunity of bringing forward that opinion in the War Office Committee on which he served, and he strongly urged then that Infantry Battalions assisted by trained artificers ought to be able

to carry out the repairs of their own barracks. If the Government would provide the workshops and machinery, and if they had the men who could teach soldiers during their term of service, it would fit them, when they return to civil life, for something better than the comparatively menial employment they at present get. General Sir Alexander B. Tulloch, a soldier of great experience, has spoken in the same strain, as has also Mr. Howard Hensman, the eminent author and journalist, who has made military matters and the life of the soldier his special study.

While we sympathise with the view that provision should be made for teaching the soldiers some trade in the army, there are one or two delicate questions to be considered here. For example would Trade Unions allow the soldier to follow his trade, when he returned to civil life. They at present restrict the number of apprentices, and some trades will not allow any one to enter after 18 years of age or so. Again, any large accession of pension-receiving ex-soldiers to the ranks of skilled labour might be tantamount to the establishment of a State Wages Fund, and so tend to reduce the standard rate of pay. The question is thus hedged with difficulties.

If the schemes I have indicated are declared by military experts to be impracticable, then, in my opinion, the short service system stands condemned, because the individual and social well-being of the soldiers must have first consideration. I think I have shown that some part at least of our social derelicts is derived from time-expired soldiers and reservists. Can nothing be done under the present system to remove this reproach from the Army? Could not these men be constrained to remain with the colours? Should not soldiering be as attractive as the mine, the workshop or the factory?

Since the realisation of the prophet's dream of swords being beaten into ploughshares seems yet afar off, could an attempt not be made to make the Army a life profession? What is there to hinder it becoming an attractive, a dignified, a worthy profession for the rank and file as for the officers? At present, few who enlist look upon soldiering as their life's work. Leaving conscription out of consideration, and assuming that our voluntary system is to continue, what is to be done? The term of service at present obtaining ranges from three to twelve years with the colours. Now, we make bold to assert, that for a considerable percentage of the men who leave the colours at the end of these periods, there is

no work to be got. In view of this, are we not forced to the conclusion that if the voluntary system is still to prevail, a long service era must again be introduced? Is, say, a 25 years' service not workable? Could not soldiering be the man's trade or profession, his life's business, and when his period of service is concluded, could he not have a living pension? It will be answered, of course, that sufficient men would not then be forthcoming for the requirements of our Army. But this cannot be admitted. It remains to be proved. For instance, in the year 1903-4, recruiting for the infantry was confined to men who engaged for long service only, and far from being unsatisfactory, recruiting that year was the biggest the Army ever had.

Is this life service suggestion then, not worthy of consideration? Are we justified in supposing that it would diminish recruiting? Is there not at least a possibility of it having a contrary effect, and greatly augmenting the recruiting returns? But in any case, is the trend of opinion at present not towards a smaller and more efficient Army, and greater encouragement to the Militia, notwithstanding the opinion of a powerful and weighty school who consider that the Army at present is ridiculously small and out of all proportion to the requirements of the Empire?

I am not concerned with those conflicting statements and cannot take time to discuss them here, but would venture to say that what keeps large numbers from the Army to-day is the knowledge that after a few years they shall return to civil life in a measure stranded. Parents, as a rule, consider the enlistment of their sons, if they are of good character, as a species of social suicide. This would, however, be all changed if the conditions of service were revised. The present state of matters will not be improved by a perpetuation of any short-service system, and the building up of a large reserve, which very soon loses all the advantages of Army discipline and morale in face of adverse civilian conditions.

This view appears to have impressed itself upon the Army Authorities, for, while the term of three years colour service was introduced into the Army, for all arms, on the 1st of April, 1902—a very appropriate date, as it turned out, for a very foolish experiment—the order establishing it was revoked on 20th October, 1904, except as regards the Royal Horse and Royal Field Artillery, Royal Engineers, Foot Guards, Army Service Corps, Royal Army Medical Corps, and Army Ordnance Corps, in

which the three years' service is still in force. Now, recruits for the infantry enlist for nine years with the colours and three years with the reserve—a precise reversal of the former conditions—but even this period is in many respects too short, and will, we fear, operate in the same disadvantageous manner as the three years' service.

Whatever may be the answer to the questions thus raised, a new and beneficent era for the soldier and the country will only dawn by making the conditions of service more permanent and coherent, and elevating the profession of arms into a more attractive and honourable calling for the rank and file. The British Army lives by voluntary enlistment, and if that system is to continue, it is essential that the terms offered by the State to the soldier should be sufficiently alluring to secure the necessary number of recruits.

In conclusion, let me say, that I think that I have shown, as was my only object, that as at present constituted, our Army does contribute, in no inconsiderable proportion to human wastage. My plea is not for Army reform *per se*, but reform of a system which every year is throwing some thousands of men adrift—men who have missed their vocation in life—trucks that have become derailed. This is a far greater question than any mere military one—it is a part of the social problem, and therefore, no contemptuous negative criticism—no mere obstruction from the military side, should be allowed to delay or prevent its careful consideration.

If no practical scheme can be devised of making the shorter service men efficient to return to civil life, then the present system, from a social point of view—my only concern here—stands, as I have said, condemned, and as, under present conditions of civilisation, our country must have an Army, let that Army be so organised, recruited and remunerated, that it will attract the best among our citizens—men who will as readily return to soldiering as to shoemaking or engineering. Thus, with a greater fixity of service, and an assurance of a living pension at its conclusion, we believe, the Army would enter upon a new era of solidarity and prosperity, and the question of its contribution to human wastage disappear from the realm of practical discussion.

The Eyesight of School Children : being a record of the examination of over 3,000 school children. By W. B. INGLIS POLLOCK, M.D.

[Read before the Society, 13th December, 1905.]

DURING the last few years there has been a very considerable increase of interest in the subject of school hygiene. We owe this in a great degree to the question of the physical degeneration of the race, which has been discussed in all manner of societies and periodicals.

The Royal Commission on Physical Education in Scotland found itself forced to discover not only the conditions which favoured, but also those which hindered physical culture, and, as a consequence, was led to recommend the medical inspection of school children.

It is unnecessary to lay stress on the importance of good eyesight in all the manifold and varied occupations of life, nor to discuss the handicap which is placed on those who are afflicted with any weakness of vision. The number of occupations is steadily increasing in which a preliminary test of the vision is necessary before the candidate proceeds to his or her training. I have examined in the course of the last eight months, by permission of the Rev. Dr. Smith and the members of the Govan School Board, the eyesight of all the pupils in three schools of the Govan School Board, viz., Elder Park, Church Street, and Hillhead High School. The two former are primary schools, while the last contains in addition a large secondary department. There are among its pupils a few French, German, Norwegian, Spanish, and Jewish scholars, but they are insufficient in numbers for a comparison with the native children.

The name, age, and standard of each child was noted. The acuteness of vision of each eye was investigated separately by means of Snellen's Test-types, and if glasses were worn it was again taken with the spectacles on. A test-type in which well-known objects replace the letters of the alphabet was used for young children. The types were illuminated by artificial light. The colour of the iris, the condition of the eyelids, the front of

the eyeball, and the fundus were then examined and noted. At the same time the refraction of each eye was taken by direct measurement with the ophthalmoscope, confirmed where necessary by retinoscopy, and checked by the results of the vision test. Colour perception was not tested, as it would have required a large amount of time to be accurately done, especially with the younger children.

VISUAL ACUTENESS.

It is not necessary for school purposes that children should have the vision of both eyes. With one eye they can read at a distance, or near at hand. The scholars have therefore been classified by their better eye. This system has anomalies, since children were returned as having perfect vision, although one eye was blind or almost so. The near reading test is not satisfactory. With it even moderate degrees of hypermetropia, or long-sight, escape detection owing to the activity of the accommodation in childhood, while it is altogether useless for the discovery of myopia, or short-sight. The vision was therefore determined by the distance test-types alone. The visual acuteness is affected by inflammation of the eyes, and such diseases are more common as a rule among the poorer classes of the population. These were fairly numerous in Church Street School, and, to some extent, accounted for the unfavourable results shown by the investigation in that school.

For statistical purposes the children have been divided into three groups according to their visual acuteness (the better eye). Table I. I have adopted the classification employed by Dr Kerr, the Chief Medical Officer of the London County Council Schools. The first group entitled good consists of all with visual acuity of $\frac{6}{6}$. The second group includes those with $\frac{6}{8}$ or $\frac{6}{12}$, and is called fair. All the others with visual acuteness of $\frac{6}{18}$ or worse are classified as defective. It will be seen that Elder Park School and Hillhead High School approximate closely, there being simply a difference of 8 or 9 per cent. between the good and the fair groups, but Church Street School is considerably worse than the other two. The reasons for this are various and will be discussed later.

Table II. gives the results for the total boys and the total girls arranged in the same groups. 1,574 boys and 1,609 girls were examined. The girls are worse than the

TABLE I.—VISUAL ACUTENESS.

ELDER PARK SCHOOL.

Ages, -	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Total.	Percentage.
Good, -	2	63	131	134	118	112	130	134	107	88	20	1	—	—	—	1040	78·07
Fair, -	2	1	17	20	22	21	19	27	12	27	1	—	—	—	—	109	12·68
Defective, -	—	7	10	13	20	19	20	13	12	9	—	—	—	—	—	123	9·23
Total,	4	71	158	167	160	152	169	174	131	124	21	1	—	—	—	1332	—

CHURCH STREET SCHOOL.

Ages, -	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Total.	Percentage.
Good, -	3	23	43	30	33	47	42	43	36	22	1	—	—	—	—	323	47·22
Fair, -	—	7	11	20	27	35	27	33	31	18	—	—	—	—	—	209	30·55
Defective, -	—	8	25	21	14	24	21	18	13	7	1	—	—	—	—	152	22·22
Total,	3	38	79	71	74	106	90	94	80	47	2	—	—	—	—	684	—

HILLHEAD HIGH SCHOOL.

Ages, -	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Total.	Percentage.
Good, -	1	31	60	69	47	83	88	79	92	86	94	42	29	12	5	818	70·09
Fair, -	—	2	10	18	27	34	39	29	37	16	21	11	7	1	1	253	21·67
Defective, -	1	2	3	6	8	11	9	8	9	10	9	7	5	6	2	96	8·22
Total,	2	35	73	93	82	128	136	116	138	112	124	60	41	19	8	1167	—

TABLE II.—VISUAL ACUTENESS.

TOTAL BOYS.

Ages, -	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Total.	Percentage.
Good, -	3	51	127	125	105	140	151	124	113	98	52	19	5	—	—	1113	70·71
Fair, -	2	5	16	32	33	43	37	43	38	34	8	4	3	—	—	298	18·93
Defective, -	—	9	17	20	18	18	24	19	15	11	5	2	3	2	—	163	10·35
Total,	5	65	160	177	156	201	212	186	166	143	65	25	11	2	—	1574	—

TOTAL GIRLS.

Ages, -	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Total.	Percentage.
Good, -	3	66	107	108	93	102	109	132	122	98	63	24	24	12	5	1068	66·37
Fair, -	—	5	22	26	43	47	48	46	42	27	14	7	4	1	1	333	20·70
Defective, -	1	8	21	20	24	36	26	20	19	15	5	5	2	4	2	208	12·92
Total,	4	79	150	154	160	185	183	198	183	140	82	36	30	17	8	1609	—

TABLE III.—VISUAL ACUTENESS.

GRAND TOTAL.

Ages, -	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Total.	Percentage.
Good, -	6	117	234	233	198	242	260	256	235	196	115	43	29	12	5	2181	68.52
Fair, -	2	10	38	58	76	90	85	89	80	61	22	11	7	1	1	631	19.82
Defective, -	1	17	38	40	42	54	50	39	34	26	10	7	5	6	2	371	11.65
Total,	9	144	310	331	316	386	395	384	349	283	147	61	41	19	8	3183	—

PERCENTAGES.

Ages, -	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Average.
Good, -	81.25	75.48	70.39	62.66	62.59	65.82	66.66	67.34	69.26	78.23	70.48	70.73	63.15	62.50	68.52
Fair, -	6.94	12.26	17.52	24.05	23.32	21.52	23.17	22.92	21.55	14.96	18.03	17.07	5.26	12.50	19.82
Defective, -	11.81	12.26	12.08	13.29	13.98	12.65	10.15	9.74	9.18	6.80	11.48	12.19	31.58	25.00	11.65

boys by 1·8 per cent. in the fair group, and 2·5 per cent. in the defective group, so that the boys have the advantage by 4·3 per cent. in the good group. The actual percentages of the defective group are 10·35 in the case of the boys, and 12·92 for the girls. Table III. contains the grand total of 3,183 school children of both sexes. The numbers are placed above, and the percentages for each age group below. Over all there are 68·52 per cent. with good vision, 19·82 per cent. with fair, and 11·65 per cent. with defective vision.

During the first four years of school life the good vision group exhibits a fall from 81·2 per cent. to 62·6 per cent., corresponding with a rise in the fair group from 6·9 per cent. to 24 per cent., while the defective group merely rises from 11·8 per cent. to 13·3 per cent. Although the picture test-type employed for the infant classes did not discriminate accurately between the good and the fair group, yet there is little doubt that these changes in the percentages prove that a very large strain has been thrown upon the eyes of the infants during their first years of school life. Thereafter there is a gradual improvement in the good group from 62·6 per cent. to 78·2 per cent. at fourteen years of age. During the same period both the fair and the defective groups decline, the former supplying about two-thirds of the improvement by falling from 24 per cent. to 14·9 per cent., and the latter, the other third, passing from 13·3 per cent. to 6·8 per cent. The eye-sight of the pupils has therefore recovered to a great extent from the strain of the earlier years. I cannot agree, however, with those observers who state that the number of children with normal vision increases with every year of school age. On the contrary, even with 78·2 per cent. at fourteen years of age the good group are not so high as the 81·2 per cent. of five years of age. It does not stand to reason that the vision of a child should improve as he grows older (I mean from five to fourteen years of age). If it is found that he is worse at five, a doubt arises as to whether the test was suited to his knowledge and understanding. My opinion is supported by the figures showing the results of the examination of 2,782 children in the infants' schools in London.¹ The percentages for the fair and the defective groups are given in the report, and from these the percentages for the good group are easily obtained. The tests were

¹ Report of the Medical Officer of the School Board of London, 1903.

very carefully carried out by three oculists, every effort being made to induce the children to take an interest in the proceedings. The good group began at 81·7 per cent. for 458 children of 6 to 6½ years of age, and fell steadily for each set of children arranged into age-periods of six months till it was 74·2 per cent. for 958 children of 8 to 8½ years. These figures are both convincing and instructive.

At fourteen years of age another change commences, which will be better understood later. Here it may be noted that the group with good vision falls from 78·2 per cent. to 63·3 per cent., while the defective group increases from 6·8 per cent. to 25 per cent. for eighteen years of age. Taking the defective group as a whole it will be seen that the variations are small during the first fifteen years of age. There were few children with very bad vision in the earlier classes. It is also true that the group may include a number of pupils of slow mental grasp or even timidity. Such factors would tend to show that the percentage of defective vision is too high for these earlier years, and if allowance were made for them the group might exhibit a greater increase than it does during school life.

Dr Kerr¹ showed, two years ago, that there is an association between defective visual acuity and retarded position in school by dividing the children into two groups of those who were older and those who were younger than the average age of their standard. The former group exhibited a much larger percentage with defective vision than the younger pupils.

The same report also shows that defective visual acuity is greatest among children drawn from poorer neighbourhoods. Among the schools in which the pupils were mostly Jewish 36·2 per cent. had defective vision. The percentage was 30·2 in the schools in crowded neighbourhoods with no wide thoroughfares to which children were likely to resort. In schools from similar neighbourhoods, but with wide thoroughfares, the number was 27·0 per cent., a fourth group of schools in more or less residential neighbourhoods had only 19·2 per cent.

The same rule applies to the schools examined here. Elder Park School—See Table I.—occupies an especially favourable situation. It is quite close to the Elder Park of Govan, through which a certain number of the children pass on their way

¹ Dr Kerr *loc. cit.*

to and from school. On its other side, a single row of houses separates it from the open country, while at a distance of quarter of a mile is the river Clyde. The neighbouring streets are broad and clean, bounded in some cases by terraces of small two-storied houses, each with its own front door. The children belong to a class in which tradesmen, steady working mechanics, and foremen predominate. Church Street School stands in a crowded district. It is some little distance from any of the city parks. A number of the surrounding streets are narrow and bounded by high tenements. The children probably belong to much the same class as those seen in Elder Park School. Hillhead High School is in one of the better residential districts of the city, and the children are drawn from a very wide circle, some even from the country. None of the schools are in the worst districts of the city. I purposely avoided such in order to exclude certain factors which might have been blamed for the results which were discovered.

EMMETROPIA.

Emmetropia, so-called normal sight, is not so common as is generally believed. Before going further I must state that all subsequent calculations and tables are based on the number of eyes and not on the number of children examined. This method avoids the difficulty of classifying the cases in which the eyes are different. A slight difference is common, but a considerable difference is not infrequent, and occasionally the two eyes have the opposite errors of refraction.

Table IV. contains the number of emmetropic eyes in the three schools at the different ages. Elder Park has a total of 45·72 per cent, Church Street 34·62 per cent., and Hillhead High School 45·58 per cent. The first and the last are again very close together. Table V. gives the total number and the percentage of emmetropia over the three schools at the various ages. The percentages of Table V. have been accurately mapped out and are reproduced graphically in Illustration I. It will then be seen that the line E shows an almost continuous rise from the age of entrance to fourteen years of age, viz., from 38·5 per cent. to 51·7 per cent. This increase is in association with the growth of the eyeball, so that it approximates more closely to the adult form. After fourteen years of age a decline occurs in the curve, which is similar to the fall of the good

TABLE IV.—ERRORS OF REFRACTION.

ELDER PARK SCHOOL.

Ages,	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Total.	Percentage.
Emmetropia,	4	56	150	146	132	115	161	165	133	131	25	—	—	—	—	1218	45.72
Hypermetropia,	4	75	137	159	150	155	139	156	110	82	13	2	—	—	—	1182	44.36
*M. Astigmatism,	—	10	20	16	22	18	13	12	8	11	2	—	—	—	—	132	4.95
Myopia,	—	1	9	13	16	16	25	15	11	24	2	—	—	—	—	132	4.95
Total,	8	142	316	334	320	304	338	348	262	248	42	2	—	—	—	2664	—

CHURCH STREET SCHOOL.

Emmetropia,	—	23	39	31	54	88	51	77	72	38	—	—	—	—	—	473	34.62
Hypermetropia,	6	47	102	92	62	87	104	87	65	52	3	—	—	—	—	707	51.76
*M. Astigmatism,	—	4	14	9	14	16	13	12	8	—	1	—	—	—	—	91	6.66
Myopia,	—	2	3	9	18	21	12	12	14	4	—	—	—	—	—	95	6.95
Total,	6	76	158	141	148	212	180	188	159	94	4	—	—	—	—	1366	—

HILLHEAD HIGH SCHOOL.

Emmetropia,	2	32	65	88	58	105	110	105	130	117	127	62	38	18	7	1064	45.58
Hypermetropia,	—	36	72	85	90	120	131	98	110	84	93	32	28	8	5	992	42.50
*M. Astigmatism,	1	—	3	8	9	15	12	10	10	3	8	2	1	2	—	84	3.59
Myopia,	1	2	6	5	7	16	19	19	26	20	20	24	15	10	4	194	8.31
Total,	4	70	146	186	164	256	272	232	276	224	248	120	82	38	16	2334	—

* Mixed Astigmatism.

vision group in Table III. It amounts to 8 per cent. *i.e.*, from 51·7 per cent. to 43·7 per cent. at eighteen years. Over all the three schools there is 43·29 per cent of emmetropia.

HYPERMETROPIA OR LONG-SIGHT.

The hypermetropic eyeball is relatively too short, *i.e.*, the images of distant objects, when the eye is at rest, are in focus behind the retina. The great majority of infants at birth are hypermetropic, but as they grow older the eyeball lengthens so that it gradually assumes the emmetropic or normal form. All eyes of less than one dioptré of hypermetropia are excluded from this group. At five years of age (Table V. and Illustration I.), this group is 54·9 per cent., but thereafter falls steadily until, at fourteen years of age, the number is 37 per cent., and then rather irregularly to 31·2 per cent. at eighteen years of age. The numbers for the three schools are given in Table IV. Elder Park School, 44·36 per cent.; Church Street, 51·76 per cent.; and Hillhead High School, 42·50 per cent. Of 6364 eyes examined there was

Hypermetropia (long-sight) .	2105 = 33·1 per cent.
Hypermetropic Astigmatism .	775 = 12·1 per cent.
Total, . . .	2881 = 45·2 per cent.

MYOPIA OR SHORT-SIGHT.

This is a subject which claims our most serious attention. Some one has said that it is the accompaniment of intellectual progress, since not only is it almost never present among savage races, and varies among civilised nations more or less according to the state of their intellectual advance, but even in the same country it is most prevalent among the learned and the teaching professions. I hope to prove that, although this combination occurs, it is not necessary, and already there is evidence of a diminution of short-sight where regulated efforts have been carried out for its prevention.

The number of myopic eyes is given in Table IV., for each school at the different ages. From Table V. and Illustration I., line My., it is seen that Myopia exhibits a steady and progressive increase at each school-age period. This rise is most marked during the higher ages, but although more gradual in the earlier period it is, nevertheless, just as ominous. At five years of age there is only 1·7 per cent. of near-sight, but at fourteen it has risen to 7·5 per cent., while

TABLE V.—ERRORS OF REFRACTION.

GRAND TOTAL.

Ages,	-	-	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Total.
Emmetropia,	-	-	111	254	265	244	308	322	347	335	286	152	62	38	18	7	2755
Ilypermetropia	-	-	158	311	336	302	362	374	341	285	218	109	34	28	8	5	2881
Mixed Astigmatism,	-	-	14	37	33	45	49	38	34	26	14	11	2	1	2	—	307
Myopia,	-	-	5	18	27	41	53	56	46	51	48	22	24	15	10	4	421
Total,	-	-	288	620	661	632	772	790	768	697	566	294	122	82	38	16	6364

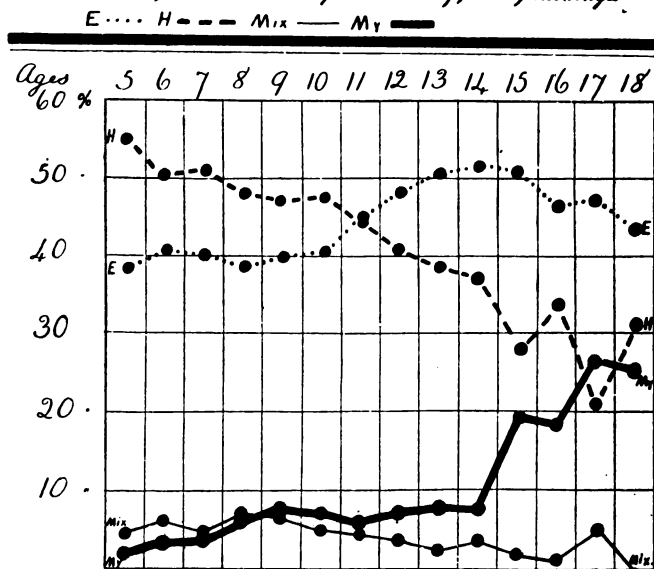
PERCENTAGES.

Ages,	-	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Average.
Emmetropia,	-	38.53	40.97	40.09	38.60	39.90	40.76	45.18	48.06	50.53	51.70	50.82	46.34	47.36	43.75	43.29
Ilypermetropia	-	54.86	50.16	50.83	47.78	46.89	47.34	44.40	40.89	38.52	37.07	27.87	34.15	21.05	31.25	45.27
M. Astigmatism,-	4.86	5.97	4.99	7.12	6.34	4.81	4.42	3.73	2.47	3.74	1.63	1.21	1.21	5.27	—	4.82
Myopia,	-	1.73	2.90	4.08	6.48	6.86	7.08	5.98	7.31	8.48	7.48	19.67	18.29	26.31	25.00	6.61

at eighteen it reaches 25 per cent. The first period corresponds to the progress of a child through the primary school, or as it used to be called, the standards, and for the most part the second age-period covers the secondary school.¹ The reason for the abrupt change in the curve at fourteen years of age is to be sought in the withdrawal from school at that age of almost all the non-studious children. Those who remain, in Board schools at anyrate, are more or less intent upon intellectual progress, and the majority of those examined were preparing for the University or Training Colleges.

ILLUSTRATION I.—ERRORS OF REFRACTION.

Obel Emmetropia, Hypermetropia, Mixed Astigmatism and Myopia in percentages.



We are thus met with the fact that *the number of short-sighted children increases at each age-period of school life*. Slight variations in the curves may be caused by the accident of the day upon which the examination was carried out. A child one day is eleven, but two days later might have to be classed as twelve, his birthday having occurred upon the intervening day. In the

¹ Some of the pupils of the secondary department in Hillhead High School are twelve, thirteen, or fourteen years of age, but the great majority of children at these ages are in the primary schools.

continental statistics the children are arranged according to classes, but again a disturbing factor is caused by scholars having sometimes to spend two years in one class. The best classification would be one based upon the number of years a child has been at school. This information, however, is not easily obtained, because of the transfer of pupils from one school to another, and the statements of the children are not to be trusted.

Table VI. contains the percentage of myopic eyes in the three schools separately, while the total percentages are repeated in the last column from Table IV., and the average line for the three schools together at the foot, from Table V. They all exhibit a progressive increase. It will be noticed that Church Street School has relatively high percentages for the ages of seven, eight, and nine. This is to be ascribed to the fact that the pupils had left a defective building shortly before my investigation. The old school had badly-lit and ill-ventilated rooms. The building was very old and surrounded by high tenements. These conditions are sufficient to account for the high percentage of defective vision and myopia. The rooms in the new building are well lit, and in almost all cases the light comes from the left side of the children, in a few rooms it is from the right. The plenum system of ventilation is in use throughout the building. The new school stands in the centre of large playgrounds, and the high buildings immediately adjoining the old school have all been taken down, while on the opposite side of the street several high tenements have given place to the two-storied out-patient department of the Western Infirmary. Altogether the surroundings are now exceptionally favourable. One might expect the older pupils of Church Street to have also had a higher percentage of myopia than they actually exhibit, but the change of residence and consequently of school, which is so frequent among the working classes, had probably diminished the effect before my investigation.

Elder Park School again occupies the most favourable position for almost all ages. The building is of recent construction and has been erected according to all modern hygienic requirements. The playgrounds are large while the nearest buildings are only two stories in height. The ventilation is on the plenum system.

The high total percentage for Hillhead High School, viz. 8·31 per cent. is accounted for by the presence of the large secondary department. The number of near-sighted eyes is only 6·56 per cent. for the primary school which compares with the 4·95 per

TABLE VI.—MYOPIA.
THE PERCENTAGES FOR EACH SCHOOL.

Ages, . . .	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Average for the whole school.
Elder Park School,	0.70	2.82	3.89	5.00	5.26	7.39	4.31	4.19	9.68	4.76	—	—	—	—	4.95
Church Street School,	2.63	1.89	6.38	12.16	9.90	6.66	6.38	8.80	4.26	—	—	—	—	—	6.95
Hillhead High School* 2.85	4.11	2.69	4.26	4.26	6.25	6.98	8.19	9.42	8.93	8.06	19.67	18.29	26.31	25.00	8.31
Average for the three schools,†	1.73	2.90	4.08	6.48	6.86	7.08	5.98	7.31	8.48	7.48	19.67	18.29	26.31	25.00	6.61

* The total percentage of myopia in the primary and infant departments of Hillhead High School was only 6.56.

† This line is repeated from the lowest line of Table V.

cent. of Elder Park, and 6.95 per cent. of Church Street School, and stands between them. The investigation was mainly carried out in the Hillhead School just before the examinations, and after a long winter's work, and probably the results are a little more unfavourable than would otherwise have been the case. The rooms are well-lit, and the windows are placed on the left side of the pupils. The school stands high, but is more crowded by surrounding buildings than either of the other two. The ventilation is on the exhaust principle.

SEX.

Table VII. contains respectively the number of eyes and of myopic eyes among the total boys and the total girls of the three schools, arranged again in ages, and gives the relative percentages. It will be seen that the two percentages run closely together, and both agree with the previous tables in proving that myopia increases as the children grow older. The girls have the higher percentage for all but four of the age-periods, viz., ten, eleven, fourteen, and sixteen to eighteen. The greatest difference between the two sexes is at the beginning and at the end of the school period. The former is the more important, because at the latter the number of boys available was rather small for comparison. The ages of five and six require special attention, since at each there are three times the number of girls with myopia as the boys. For the boys, of 3137 eyes there are 201 myopic, or 6.40 per cent., while the girls with 3209 eyes have 219 myopic or 6.82 per cent., contrasting with a percentage for the total boys and girls of 6.61. Sewing has been generally blamed for the larger number of myopes in the female sex, and I see no reason to doubt it.

MIXED ASTIGMATISM.

Between the conditions of long-sight and near-sight there is a state of refraction named mixed astigmatism. This is a stage in the series of changes by which the hypermetropic eyeball becomes myopic, and indicates that the eye is already partially myopic. In Table IV., will be found the number of mixed astigmatic eyes. Church Street School is again worst, while Hillhead High School has the best result, but of course over the two departments, primary and secondary. As will be seen from Table V., and Illustration I., line Mix., mixed astigmatism is most frequent

TABLE VII.—MYOPIA.—THE TOTAL BOYS.

Ages, -	5	6	7	8	9	10	11	12	13	14	15	16	17	18	16-18	Total.
Total Eyes, -	130	320	353	312	402	424	372	332	286	130	50	22	4	—	26	3137
Myopic Eyes, -	1	5	14	20	26	32	24	23	24	13	9	7	3	—	10	201
Percentages, -	0.8	1.5	3.9	6.2	6.4	7.5	6.5	6.9	8.4	10.0	18.0	31.8	75.0	—	38.4	6.40

THE TOTAL GIRLS.

Ages, -	5	6	7	8	9	10	11	12	13	14	15	16	17	18	16-18	Total.
Total Eyes, -	158	300	308	320	370	366	396	365	280	164	72	60	34	16	110	3209
Myopic Eyes, -	4	13	13	21	27	24	22	28	24	9	15	8	7	4	19	219
Percentages, -	2.5	4.3	4.2	6.5	7.3	6.5	5.5	7.7	8.6	5.5	20.8	13.3	20.6	25.0	17.3	6.82

TABLE VIII.—MYOPIA.

TOTAL NUMBER OF MYOPIC AND MIXED ASTIGMATIC EYES, ARRANGED IN THE DEGREE OF SHORT-SIGHT.

Ages, -	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Total.	Percentage.
0-1 D. -	2	15	44	44	70	87	69	56	36	42	22	13	5	5	—	510	70.05
1-4 D. -	—	4	11	14	12	13	23	24	34	18	9	13	8	5	—	188	25.83
4-10 D. -	—	—	—	2	4	2	2	—	7	2	2	—	3	2	4	30	4.12
Total, -	2	19	55	60	86	102	94	80	77	62	33	26	16	12	4	728	—

in the earlier years of school life, and from the age of eight it exhibits a progressive decrease. The true relation of these figures to the causation of myopia will be discussed later.

THE DEGREE OF MYOPIA.

Although it is generally known that those who are near-sighted tend to become more near-sighted, yet individuals who are myopic, do not often admit that their myopia has increased. It is therefore of interest to find what light is thrown upon this aspect of the subject by my investigations. We have already discovered that the number of myopic children is constantly increasing as the children become older. The question is, do such children remain of the low degree of near-sight in which the myopia originated, or does the amount of myopia increase? To answer this question, the myopic eyes and the mixed astigmatic eyes have been arranged in three groups according to the degree of myopia. The first includes all of less than one degree of near-sight (one dioptré); the second those between one and four degrees (one to four dioptrés); and the third all over four degrees, reaching, in fact, ten degrees in one case (four to ten dioptrés). Table VIII. gives the result arranged according to ages.

In the case of myopic astigmatism the average was taken, and entered in the corresponding group.

Illustration II. exhibits the percentages for the different ages, of each group to the total myopic eyes for the respective age. The curve of the first group exhibits a distinct and progressive decrease. Commencing at 100 per cent. by the age of eighteen it has fallen to 0 per cent. The second group, on the other hand, increases in a somewhat irregular fashion during the first two-thirds of school life, and then maintains its position, except for the age of eighteen when it likewise falls to 0 per cent. The third group, consisting of eyes with a fairly high degree of myopia, presents an almost continuous rise in numbers. It does not appear until seven years of age, which means that two years or even three years of school life have been sufficient to produce this rapid development of myopia. At sixteen years of age almost 20 per cent. of the myopic eyes are included in this group while at eighteen the entire number belongs to it (100 per cent.). In other words 25 per cent. of the scholars at eighteen years of age are myopic, and each has over four degrees of near-sight.

There is thus very distinct evidence that *the number of eyes*

with the higher degrees of myopia or near-sight, increases at each age-period of school life. But, since the number of myopic eyes is constantly increasing and since the myopia commences in each individual gradually from nothing, being at first less than one degree, it is clear that *the majority of children who have become myopic in school, exhibit a continual increase in the degree of their near sight.*

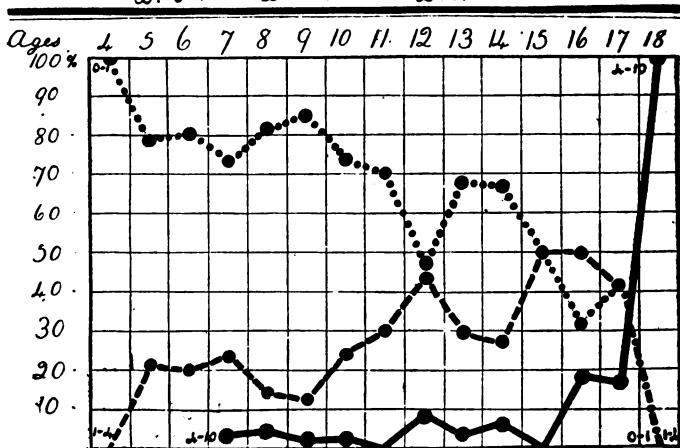
CAUSATION OF MYOPIA.

Myopia may be defined as that refractive condition of the eye in which images of distant objects are in front of the retina, *i.e.*, the

ILLUSTRATION II.—MYOPIA.

Grade of Myopia of pupils of all three schools in percentage to total Myopia at each age.

D. 0-1 ... D. 1-4 --- D. 4-10 —



eyeball is relatively too long. Although such a condition may originate otherwise, we have here to deal entirely with an elongation of the globe. The normal eye closely resembles a sphere, but the myopic eye is longer from before backwards than in any other diameter. The coats of the eye are so elastic that the ball may be dimpled by pressure, but immediately the pressure is removed, it resumes its normal shape. During childhood and youth the eyeball may undergo a change of form by long continued pressure from within or without, but after adult life is reached it is rare for such a process to originate in the healthy eye. In near

work the eyeball is compressed from all sides by muscles except in front and behind. If the pressure be maintained long enough while the coats of the eye are not firm, the eyeball gradually assumes an elongated form. It is, therefore, in childhood and youth, when the whole body is growing, that the strain of near work develops myopia. This has been confirmed by observations from all over the world, that myopia occurs almost exclusively among those who are constantly studying or performing fine work, like tailors, composers, or needle-women, etc. In proof of this statement we have statistics on the eyesight of school children from almost every country, and mine support them. They show that the more years the near work continues, the greater is the number of short-sighted eyes, and the higher the degree which the myopia reaches. Cohn's¹ statistics, drawn from the examination of over 10,000 school children, are widely known and it is unnecessary to repeat them in this paper.

A number of observers have shown that a higher percentage of myopia occurs among purely classical scholars than among pupils of technical schools, while mixed schools occupy an intermediate position. This has been blamed on the constant bookwork, and the frequent reference to dictionaries, especially as those usually found in the scholars' bags are badly printed and have very compressed type. Laboratory work on the other hand does not strain the eyes to the same extent, nor so continuously. Myopia is rare among country children. A life spent mainly in the open air leads to a strong physique and consequently greater powers of resistance in all the organs of the body. The town child is more confined to the house, and even when outside his prospect is too often limited by the other side of the street.

With regard to the prevalence of myopia among the different classes of the community, Tscherning's statistics are of interest. He examined 7,523 persons liable for military service in France, and found that 2 per cent. of country workers had myopia; 5 per cent. of town labourers; 12 per cent. of artisans; 16 per cent. of printers; and 32 per cent. of students. Cohn found that 59 per cent. of the students of the University of Breslau were myopic; while Priestly Smith reported that it occurred in 20 per cent. of the students of the Birmingham Teachers' Training College.

¹ "The Hygiene of the Eye in Schools." By H. Cohn, M.D., Breslau. Translated by W. P. Turnbull. Simpkin, Marshall & Co., 1886.

There is therefore no doubt that the causation of myopia lies in continuous near-work if commenced in early life. Those who say that myopia is an adaptation to the exigences of modern life, must prove that near-sight is beneficial to the individual. It is, however, quite the other way. Myopia is frequently accompanied by painful symptoms. It is very often progressive, more especially in youth and early adult life. The progressive cases are nearly always followed by changes in the retina and the choroid, due to the stretching of the eyeball, changes which cause the deterioration of vision. Professor Widmark, of Stockholm, has recently reported the result of the treatment of myopia in his private practice. In the last 500 myopic eyes he found that as the myopia increased in degree, the best vision, by the aid of glasses, progressively decreased. In high degrees of short-sight the vision may become extremely poor.

The fact that only a certain number, although a high one, of those who are subject to the strain of near-work become myopic, has led to the discovery of factors which favour the production of myopia in any given case.

I.—NEAR-WORK.

All circumstances which compel the eyes to be brought too near to the work are especially dangerous. These are of two classes, viz., those which affect the individual, and those which are external. The former include all the causes of the diminution of vision. When the sight is weak, the book or the sewing is taken closer, because the nearer to the eyes the larger is the image formed upon the retina, and consequently the more distinct the object becomes. The farther away the book is taken, the smaller does the print appear. The defective visual acuity may be the result of opacities on the front of the eyes. One should therefore take great care of all inflammations of the eyes. On the other hand, the defective vision may be due to hypermetropia (long-sight). This is particularly the case when it is complicated by astigmatism. If we revert to the curves in Illustration I. it will be noticed that the myopic curve is almost the hypermetropic curve inverted. That is a most important fact. In other words, the increase of short-sight in school children is drawn from the long-sighted and not from the emmetropic (normal-sighted) except to a very limited extent. It may be of interest to describe the changes by which this result is attained. The hypermetropic eye

with astigmatism first becomes less hypermetropic, then it passes into the condition of mixed astigmatism. As the process advances the hypermetropic element decreases, while the myopic element increases, until the former also becomes myopic. Ultimately the condition of myopia with astigmatism is reached, with a tendency to increase later. The change is not through emmetropia. Mixed astigmatism is therefore an index of the number of long-sighted eyes which have commenced to elongate unduly, and are in course of developing myopia. It has already been mentioned that this process is most active in the earlier years at school. Nevertheless, it may commence at any school age, as shown by the rise in this curve at the age of seventeen. (Table V. and Illustration I.)

The external factors which necessitate the eyes being brought too close to the work are various, and they will be considered in detail later. Insufficient light, especially with fine work, is one of the most important. If one is reading by the window as dusk is drawing near, it will be observed that the print must be brought nearer and nearer the eyes as the daylight diminishes. Others are too fine work, badly printed books, and ill-fitting desks, etc.

2.—HEREDITY.

Heredity has been popularly believed to be the origin of short-sight. A number of observers in carrying out investigations upon the eyesight of school children, have made special enquiries upon this point. Some merely asked the children if their parents were near-sighted, or if they wore glasses; but such questions are useless, as the information gained from them is wholly unreliable. The popular beliefs of what is long-sight, or short-sight are frequently quite at variance with the actual facts of the case. Others went a step further by sending printed questions to the parents of the children; but even then the information, although more reliable, is still open to the same objection. The most accurate results have been obtained from the private records of oculists in Germany and elsewhere. To be valuable such records must be upon a large scale, and this is only possible to the surgeon of long standing practice, who has had the opportunity of examining both the parents and the children. From *a priori* considerations we may say that myopia is not directly hereditary, because it is very rare for an infant to be born myopic, indeed the great majority of myopes turn near-sighted during school life. On the other hand, if myopia were hereditary we

should expect a very much greater increase in prevalence than actually occurs. It is frequently found where one parent is, and occasionally where both parents are myopic, that the children are hypermetropic or emmetropic, and none are myopic; while the reverse is equally common. It is, therefore, difficult to formulate a definite rule upon this question, but it is probably true that where the parents are myopic, the chances are double for their children, as compared with others, becoming myopic under suitable conditions. We must, therefore, recognise that such children having a tendency to myopia, require all the greater protection against its incidence.

3.—ANTHROPOMETRY.

Certain investigators have found that the orbital index is lower in myopia than in emmetropia or hypermetropia. They point out that if this is true the occurrence of a shallow orbit predisposes to the elongation of the eyeball during growth, instead of allowing the eye to increase equally in all directions, like a sphere. These results, however, have not been confirmed by all observers, and even if true they do not minimise the evil effects of bad school hygiene. Factors such as the low orbital index may explain the greater prevalence of myopia in some countries than in others. The broad, low face of the Germans, the Russians, the Chinese, and the Japanese, may, therefore, account for the frequency of myopia among the learned of these countries. The narrow and rather longer type of face found in France and Great Britain would thus be in association with the lower preponderance of near-sight among us.

PREVENTION OF MYOPIA.

The prevention of myopia is a very important branch of school hygiene, the study of which originated from the publication of Cohn's work in 1866. The first, however, who directed attention to the relationship of myopia and school work was James Ware,¹ who found that in the military school of Chelsea only 3 pupils out of 1,300 had short-sight, while of 127 students at Oxford there were 32. Since Cohn's work appeared, a vast improvement has taken place not only in buildings and benches,

¹ James Ware, Observations relative to the near and distant sight of different persons. *Philos. Transact.* London, 1813. Vol. I., p. 31.

but also with regard to all that concerns the scholars. It may be of interest to indicate the general lines along which progress has been made, and at the same time to point out certain improvements as well as the importance of a regular inspection of all school children by an oculist.

BUILDINGS AND LIGHTING.

Formerly almost any old building was thought good enough for a school, but fortunately a great advance has taken place in this direction, particularly among our public schools, although it is doubtful if the same can be said for the smaller private schools. A school should stand clear of all surrounding buildings not only for fresh air, but also to let every scholar's bench obtain, if possible, a certain amount of direct light from the sky. This is usually managed by placing the school in the centre of the playground and near vacant spaces, although in the centre of towns the high value of land militates against these proposals. The windows are best on the pupils' left, *i.e.*, on the teacher's right hand. This prevents a glare shining into the eyes of either scholars or teacher. If the illumination should be insufficient, light may also be obtained by extra windows on the right hand, but cross-lights are best avoided. Trees ought not to be allowed near the school, as the foliage darkens the rooms too much. Drawing and sewing rooms should be on the uppermost floor and be lit from the roof. In certain continental schools photometers are employed to find the amount of light at each desk. Seats below a minimum of 10 candle power on dark days are excluded from use. For the dull days of winter artificial illumination is necessary. Electric light is the most convenient for school work as it does not vitiate the atmosphere. There should be sufficient lights for all the benches. A good standard for telling when to turn to artificial illumination is a set of test-types. When it is too dark for a normal sighted person to read them at the proper distance, daylight has become insufficient.

DESKS AND POSTURE.

School desks have to be suited to the height of the children so far as possible, because a wrong seat conduces to a bad posture. Pupils while at work should sit upright. Too low a desk leads to sitting with a curvature of the spinal column, because as the child becomes tired he falls forward on the desk, and his head comes too

near his work. When the desk is too high the child cannot raise his head far enough off the paper. From these requirements the following dimensions have been deduced. The height of the seat should correspond to the length of the leg below the knee, while the height of the desk should be such that the elbows just touch it when the arms are hanging by the sides. All seats must have backs because fatigue very soon brings on bad posture. There must be an arrangement for holding reading books at an inclination of 40° , and the teacher should see that it is used. Most modern desks are made according to these regulations, but our school authorities still supply one size to each class-room. There is frequently a difference of eight or twelve inches between the height of the tallest and the shortest children in a class, and even the best desk cannot be expected to suit such variations. The ideal system is to have single adjustable desks for each pupil and this is done in certain American schools. Some English schools on the other hand keep four standard sizes in each class room, and that appears to be the more economical system.

READING AND WRITING.

All school books should be easily legible at a distance of 16 or 18 inches from the eyes. This allows the children to sit upright and yet to rest the books on the desks. Such a distance tends greatly to relieve eye strain. It is probable that the print should be distinct at a slightly longer distance, so that upon dull days it may be legible at the sixteen inches. The school books of the present day are generally well printed, especially for the younger classes. The size of the type, the width between the lines, and the distance between the letters, are points to which attention has been paid. Some of the books for the highest classes are not quite so good. Mathematical, German, and Greek text-books should be particularly good, as they are more read by figures and letters and not syllables as in English books. Javal, an eminent Paris surgeon, pointed out that in reading our eyes follow a horizontal line just immediately under the tops of the letters. This can be confirmed by covering first the upper half of a line of print and then the lower half, and comparing the legibility, when it will be found that the print is more easily read in the latter case. I am sorry to say that the majority of parents allow their children to use bibles printed in small type. There is no reason why this should be the case, for well-printed bibles may be

obtained at a very moderate cost. It is also important that good paper should be used for school books since it helps to show up the print ; whilst bad paper tends to render the type indistinct.

Writing occupies a great part of school and university life. In the higher classes of the school as well as of the university too many teachers insist upon the pupils and students taking notes to dictation. That system cannot be too strongly condemned for many reasons. The penmanship suffers, since the necessity of writing rapidly leads to the most slovenly scribbling in the majority of cases. Too often such notes are illegible, when, of course, they are worthless, and the entire lecture has been lost ; or at the best, their reading is a weariness of the flesh. Most students fail to retain any mental recollection of the subject of the lecture because the whole attention must be given to the writing. In the course of rapid note-taking bad habits of posture develop, so that the eyes and the spinal column suffer, whilst the sight is again strained in deciphering the notes. In these days of cheap printing, when we can select from so many text books on every subject, it is possible to obtain more accurate and more detailed information than is given in lectures. The lecturer is free to devote attention and explanation to the more difficult matters when he knows that his students can obtain everything else from text books. When he wishes to give his own views, he ought to supply printed sheets. There has been considerable discussion as to what style of writing is best for good posture and eyesight. Excessive sloping or angular writing is undoubtedly harmful, but I believe that a slight slope is not prejudicial, while it is easier than an exact vertical.

The posture during writing is of the greatest importance. When young children are left to their own devices, half of them are observed to bend down over their writing so that their eyes may be as near the paper as six inches or less. The current belief is that these children have weak sight and require to approach their work to see distinctly. Such an idea is absolutely wrong. My examination has shown that 85% to 90% of young children have almost perfect vision. There are only 10% with defective sight. To allow the remainder to take their books close to their eyes is giving them the greatest possible chance of injuring their eyesight and leaving damage which will never disappear. The nearer the eyes are taken to the work the greater is the strain upon them, and the greater the liability to the development of myopia. Once the coats of the eyeball have yielded to pressure, it is impossible

to say when they will cease to yield. A twelve-inch working distance is the minimum for children.

STRAIGHT HOLDERS.

With any tendency to short-sight a child instinctively draws his reading book or his writing copy nearer. Imperfect vision also urges the same approximation so that a larger retinal image may be obtained. With many children as well as adults it is simply a habit, which can be broken off with a little perseverance. For all such cases various forms of straight holders or face rests have been devised. Kallmann's Face Rest is simply an iron loop covered with india rubber at the end of a vertical rod, resembling the frame of tennis racquet. It is attached to the front of the desk and fixed at such a height and angle that the face looks through it but cannot approach nearer to the desk than a definite distance. Complete freedom is given to the arms. Durr's Horizontal Reading Support is much better and simpler. It is a horizontal rod covered with indiarubber held up by a support at each side of the desk so that it can be fixed at such a height as to catch the forehead and prevent the head reaching closer to the desk. It is upon exactly the same principle as the bar across the carriage window in a corridor train. I would strongly urge school authorities to introduce one or even two to each classroom below the second Standard. The worst sitters might be placed behind them and they would act as a deterrent to the others. Such a contrivance cannot injure the little ones, and will be of a great assistance to the teachers, while its cost need not exceed one or two shillings. Dr. Kerr has also recommended them in the London County Council schools.

SEWING.

I have been informed that a large amount of the sewing taught in school is of no practical utility, in fact a great deal is merely for exhibition purposes. We are living now in the age of sewing machines, as one will be found in almost every house, even to the one room and kitchen dwelling in the poorest districts of the city. Great attention is paid to "back-stitching" and to "over-casting," and when these are done with fine stitches they are dangerous to the sight. The sewing machine may be made to overtake the great bulk of the work carried out in school and also by repeating to do "back-stitching." One is glad for æsthetic as

well as for medical reasons that the making of wall decorations and texts in worsted on a canvas background is gradually being given up, although they are still seen in the country. The children should be taught to use the sewing machine, to darn all kinds of garments, and more attention should be given to the designing of clothing, and the "making-down" of garments for smaller children than to actual sewing. I have been consulted by a considerable number of young ladies with eye troubles which have arisen from the strain of "drawn-thread work." It is to be hoped that this kind of work may ultimately be undertaken by the machine.

The following points are of importance:—Children under seven years of age should not be allowed to sew. Sewing classes should have the best lit rooms in the school, and they are best held as near mid-day as possible, at any rate in winter time. Attention may again be drawn at this point to the discrepancy between the boys and the girls of five and six years of age in Table X., because it is just at these ages that the girls are taught to thread needles, an operation which always throws a great strain upon the eyesight.

THE HOURS OF STUDY AND RECREATION.

The hours of study should be arranged so that desk work alternates with distance work. Five or ten minute intervals are useful at the end of each hour of work in order to let the eyes as well as the brains have periodic rests. Some of these breaks may be occupied with class exercises. I wish you could see the children performing this classroom drill. No time is taken to get into position as half of the children stand at the end of each desk. Three minutes exercise and the class are again at work. These exercises should be repeated thrice daily in the infants' classes.

Kindergarten teaching, with fine work abolished, and black board drawing are partly recreation, and as such are valuable adjuncts in the infants' time table. The dust caused by the chalk is troublesome, no doubt, but perhaps a substitute for it may yet be devised. Drawing exercises in which all fine lines are absent, are also useful and do not strain the eyes. In Church Street School young ones of five and six had in this manner made very presentable coloured drawings of apples, fishes, etc.

SPECTACLES.

When the vision is so poor that a child cannot read ordinary print at fourteen inches, or large type at eighteen inches, and if such a defect is remediable by glasses, the child ought to have spectacles. Hypermetropia, and especially hypermetropic astigmatism are the commonest causes of pain and headaches and eye-strain; and if uncorrected are frequently converted by continuous near-work into myopia with deterioration of the vision. The correct spectacles will protect during school life. It is by no means necessary for them to be always worn, and much less necessary for their use after the children have left school and are at work. When myopia has commenced the best protection against further increase is in the wearing of the correct glasses.

It has been found in the London County Council Schools that the children who have been certified by the oculists as defective may not be taken to a doctor or an eye hospital, or if taken to one or the other that the parents do not purchase spectacles where these are necessary, and have been prescribed. The County Council (December, 1905) took the opinion of counsel as to whether spectacles might be supplied at the cost of the rate-payers. The counsel's opinion was negative, and, in consequence, a very influential association has been formed to supply spectacles at wholesale prices to the parents of school children, on the prescription of a doctor, as they find that the difference between the wholesale and the retail price is "very considerable." In cases of real poverty the price will be reduced. In the Glasgow Eye Infirmary the optician is under contract to supply spectacles at as low a price as one shilling. The Glasgow School Board have already supplied spectacles to the very poor. Needless to say it is essential that the glasses should be correct. It occurs at times that children are found wearing the wrong glasses, and I have also seen children wearing spectacles when they were quite unnecessary.

HOME WORK.

All these matters apply with greater force to the home work, since it has to be performed by artificial light. The children are often mentally and physically tired. We have to remember that the nervous mechanism of the eyes is especially liable to fatigue, and, in consequence, impressions are not taken on so well, and they may not be carried to the brain. The more tired the child

is, the closer the book goes to his eyes. The parent or guardian must see that the child sits upright and in a suitable relation to the light when doing lessons. Music books require to be well lit, as new music is learned note by note. Miniature editions are not for children. It is almost unnecessary to say that reading by firelight is very prejudicial, and that reading in bed is rarely carried out under favourable circumstances. One or other hygienic single desk, or some suitable arrangement, I recommend to parents of children who are already myopic.

CONCLUSIONS.

We have seen that there is a progressive increase throughout school life not only in the number affected with myopia, and also in most individual cases in the degree of the myopia. These results have been obtained in schools in which the children come from the middle class and the steady working classes. It cannot therefore be said to be due to defective home influences or poverty of parents. It has been shown that myopia is only subordinately associated with heredity, and that it is due to the school work. School hygiene has already done much to mitigate many of the worst evils associated with school life, but so far it has only led to a slight decrease in myopia. Even recently 60 per cent. of the students in certain German universities were myopic; while, although not so bad as a rule in this country, the same was true of at least one-half of the advanced medical students in last year's large class in Dr Fergus' clinique at the Eye Infirmary. It is therefore necessary that something more should be done. There is a very general consensus of opinion that there ought to be a medical inspection of school children. I do not wish to enter upon the larger question, but to emphasise its importance for the eyesight.

The results from Sweden, where a complete system of inspection of school children by ophthalmic surgeons has been in operation since 1895, are conclusive proof of the value of regulated efforts against myopia. Table X. is a synopsis of the official yearly reports, and shows a steady and regular fall in the total percentage of myopia both for the whole school and for the secondary departments taken separately. The number of children in the schools varies between 14,000 and 16,000 yearly. There has also been a decrease in the number of children with the higher degrees of myopia. Such a result is extremely satisfactory, and augurs well for the future.

TABLE X.—THE PERCENTAGE OF MYOPIA AMONG THE PUPILS OF ALL THE FIVE CLASSICAL AND HIGHER SCHOOLS IN SWEDEN. 1895-1901.¹

Class.	1895.	1896.	1897.	1898.	1899.	1900.	1901.
1	5·2	5·9	4·0	4·7	4·3	4·7	4·2
2	5·8	6·5	5·5	4·8	5·6	5·3	5·0
3	7·8	5·8	6·8	6·2	6·4	6·1	5·2
4	9·1	8·7	7·1	7·9	7·6	7·3	8·1
5	11·8	10·8	9·9	9·1	9·8	9·2	8·7
6	15·8	15·0	11·9	13·2	11·6	12·6	11·5
7	19·7	18·7	16·5	15·9	15·3	16·1	14·2
8	22·6	20·9	21·4	19·8	17·7	17·0	18·5
9	24·6	22·1	22·6	22·8	22·1	19·6	19·5
Tl. Sch's,	10·9	10·4	9·5	9·4	9·2	9·1	8·8
Number of Scholars—1895, 14,310; 1901, 16,745.							

The recent report of the Inter-departmental Committee appointed in March, 1905, by the President of the Board of Education in London, declared with regard to medical inspection already undertaken that

- “4. To nothing probably has more attention been paid than to the eyesight, and in no direction have beneficial results more certainly been obtained. Defects have been discovered which would have otherwise past unnoticed, and spectacles have been provided. Overstraining of the eyes has often been stopped, with consequent disappearance of many headaches and much apparent stupidity.
- “6. Teachers have been led to take a more intelligent and more sympathetic interest in the physical welfare of the children placed under their care. Ventilation is better attended to as its importance becomes more fully realised. The school medical officer gives teachers valuable support in any effort they may make to arouse the better feelings of the apathetic or negligent parent.
- “7. Generally we feel no doubt that the medical inspection has done much towards bringing to view defects, the treatment of which secures the child from unnecessary suffering, and may save him from serious trouble in later life. Finally, we desire to point out how small is the expenditure which inspection involves; in no urban area does it require more than 1-10d. rate, generally not so much.”

¹ From Widmark Johan, Ueber das Vorkommen der Kurzsichtigkeit in der höheren Djursholmer Schule. *Mitteilungen aus der Augenklinik des Carolinischen Medico-Chirurgischen Instituts zu Stockholm.* Heft 6. 1904.

Medical Inspection is already instituted in London where there are six oculists working under Dr Kerr, the medical officer to the London Council schools. Five of these give three half days per week to this work. It has also been carried out in many towns in England, and in the following countries—Germany, Switzerland, France, Sweden (where it is compulsory), and America. Of course, our public schools as well as the industrial and reformatory schools have been under medical inspection for a very long time. With respect to the eyesight a considerable amount of work may be performed by the teachers, viz., by providing them with test-types, when they are able to eliminate all who fail to come up to a certain standard. Where teachers have been doing this it has been found that they incline to make out a larger percentage with defective vision than the true one, but that is an error on the safe side. The Glasgow School Board has pursued this course during the last year, and as a result very large numbers of children with defective vision have come to the Eye Infirmary, where the consequent, and at times unwarranted, embarrassment of work has occasionally almost led to a breakdown. The tests which the teachers can perform are not sufficient to detect many of the cases of eye-strain. The discovery of diseases of the eye not only requires one trained in medical ophthalmology, but also in the bacteriology of the diseases of the eye. The prevention of the spread of infectious troubles of the eye is just as important as the prevention of diphtheria or scarlet fever. Some have suggested that the inspector of school children should be the medical officer of health for the district in which the school is situated. This course may be advantageous for such branches of the duties as are identical with the public health service, but for eye-work a specially trained assistant is necessary, whether he should devote his whole time or part of his time to the school duties is related to the amount of work, and to the salary provided. The London County Council obtained the oculists from among the younger specialists by demanding from each three half days per week. It would be difficult to get a competent man to give his whole time to the work, because the subject is so special that there would be no promotion.

The eyes of all children should be examined upon entering school and provision made for notifying the teaching staff of any modification necessary in their training. The examination should be repeated four years later, and again the year before

leaving school, in addition to the vision tests carried out by the teachers yearly. By these means the development of myopia would be detected at its commencement, and efforts could be made to prevent extension, if not to lead to a cure before permanent damage had been done. At the last examination the doctor might warn parents or guardians if the eyes did not appear capable of standing certain occupations or trades, or if the early use of glasses appeared necessary, when such necessity might cause a man to be thrown out of his trade in his prime. Surely, if we can do something to save the eyesight not only of our professional but of all our workers for their daily bread, it behoves us to do it. The disease, for myopia is a disease in the true sense, commences in the school-room, and it must be stamped out in the school-room.

Objection may be raised against the inspection of the eyesight of our school children, on the score that if performed for the eyes it ought to be carried out for the ears, the teeth, etc. But there is one very decided difference between these organs. It has never been shown that the ears or the teeth have been made worse by school work, but I have proved that the vision deteriorates in consequence of bad books, or defective school hygiene, and that a complete inspection of the eyesight will lead to decided improvements. Others may object that this is the thin end of the wedge of socialism. To them I would reply that the question is urgent, and the expense is slight. I should also point out that when you compel children to go to school you must see to it that their bodily organs are not injured in consequence of school life.

I began with the question of physical degeneration, and I wish to end by reference to it. The eye is but one of the organs of the body, and attention ought to be directed to the welfare of the whole, because when we improve the general *physique* we improve all the individual organs of the body. There is also no doubt that a healthy condition of our frame is antagonistic to the working of almost all morbid processes, and it will certainly improve the resisting power of the eyeball to the various influences, which have been described. Out-door games and recreations, with gymnastics indoors, are means to improve the *tone* of the system, and as such they ought to be included as an integral part of the education of childhood and youth. They do not require any great amount of time—too much may be as disastrous as none—but regularity and precision are essential.

Heusler's Magnetic Alloys. By J. G. GRAY, B.Sc., *Secretary of the Mathematical and Physical Section.*

[Read before the Society, 14th February, 1906.]

IN 1903, Fr. Heusler announced his discovery of an alloy consisting of manganese, aluminium, and copper, which, in spite of the fact that it contained none of the so-called magnetic metals, iron, nickel, and cobalt, exhibited striking magnetic properties. The discovery was in the first place accidental. When engaged in working a specimen of the alloy Heusler noticed that the filings produced were strongly attracted by the tool. Astonished by this result Heusler went systematically to work and produced specimens of the alloy in which the relative amounts of the constituents present were varied. The magnetic properties of these specimens were then tested, and the remarkable result was brought out that the susceptibility of the material reached a maximum when the aluminium and manganese were present in atomic proportions. These specimens were also subjected to extensive thermal tests, the results of which are set out in Herr Heusler's paper.

Heusler's discovery aroused comparatively little interest in this country at the time of its publication. At the 1904 meeting of the British Association a specimen of the alloy was exhibited by Mr. R. A. Hadfield, and in 1905 Fleming and Hadfield published a paper dealing with tests carried out on specimens of the alloy prepared at the Hadfield Steel Works. Since that time a number of papers on the subject have appeared in various scientific journals. They serve in the main to emphasise the fact that different samples of the alloy possess very different magnetic properties.

At the beginning of the winter session, 1904, an attempt was made to obtain some of the alloy for use in the Physical Laboratory of Glasgow University. Dr C. E. Fawsitt, of the Chemical Department, succeeded in producing specimens which were very retentive of magnetism. Unfortunately, however, owing to the lack of a suitable furnace, we were unable to prepare specimens suitable for quantitative work.

In the meantime two specimens had been obtained from Germany. The first of these rods experimented with had the composition 16% manganese, 8% aluminium, a trace of lead, and the remainder copper. It was ground truly cylindrical on emery, placed in a magnetising coil and tested by the magnetometric method. At first the specimen was found to be practically non-magnetic. As it was from the same pouring as a further specimen which exhibited strong magnetic properties we concluded that the high temperature to which the specimen had been brought during the dressing operations had destroyed the magnetic qualities, and an attempt was made to restore the magnetic properties by thermal treatment. The rod was heated to 400° C. in a furnace and then cooled slowly. After having been placed in a magnetic field and withdrawn, it was found to retain a considerable amount of magnetism. It was next heated to 340° C. for about twenty minutes and allowed to cool, when it was found that the magnetic properties were much more pronounced. With the specimen in this condition it was put through a cycle of magnetisation, the results of which are exhibited in curve 1 of the diagram.

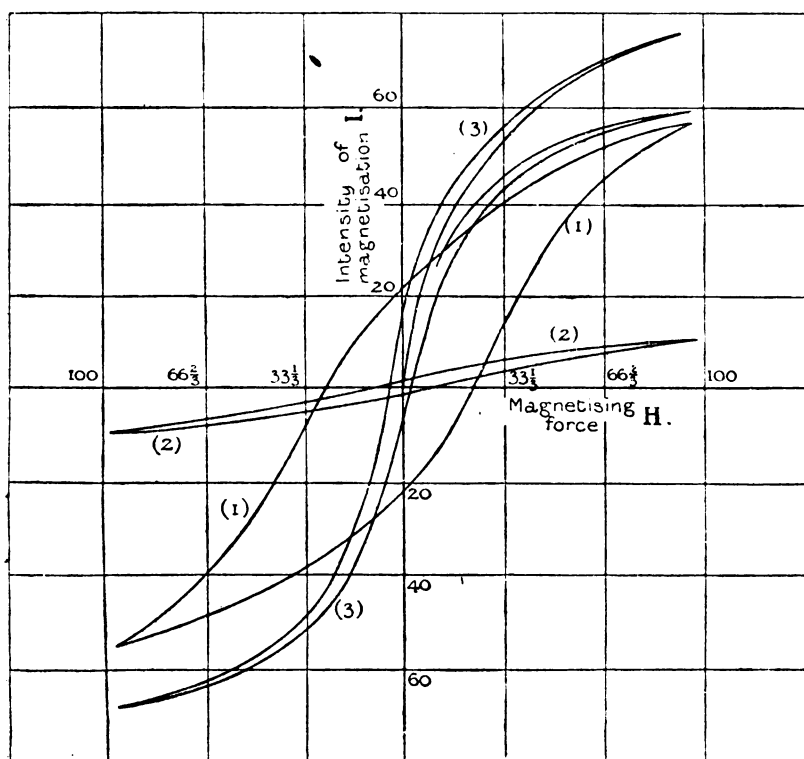
It was now decided to try the effect of an extremely low temperature upon the specimen. It was immersed in liquid air, withdrawn, and put through a magnetic cycle as quickly as possible. The effect was extremely slight, but was towards an increase in magnetic susceptibility.

An endeavour was now made to get the specimen into a better magnetic condition by heating to various temperatures, but no improvement was obtained. Incidentally the critical temperature was found to be about 350° C.

An attempt was next made to destroy the magnetic quality of the material. It was thought that sudden cooling or quenching from the above critical temperature might permanently destroy the magnetic quality, and such was found to be the case. The specimen was heated to 400° C. in the furnace and then plunged vertically into cold water. Curve 2 of the diagram, which exhibits the results of a magnetic cycle carried through with the specimen in this condition, shows the alloy to be in a comparatively non-magnetic condition. An examination of the specimen showed it to have several cracks distributed over its surface as a result of the quenching, and this probably affected the magnetic tests to a certain extent.

The effect produced by the temperature of liquid air upon the

material in its quenched and, at ordinary temperatures, nearly non-magnetic condition was now investigated and found to be very remarkable. When tested at the temperature of liquid air the specimen was found to be more susceptible to magnetism than in its previous best condition, while it exhibited very much



less hysteresis and retentiveness. Curve 3 of the diagram illustrates the new magnetic condition and shows how, moreover, the comparatively high susceptibility thus given to the alloy disappeared as the temperature rose. Curve 2 of the diagram was repeated after the temperature of the specimen had again become normal.

Curves analogous to 1, 2, 3 of the diagram have been obtained from specimens of nickel and steel. In the case of nickel the three curves differed only very slightly. On the steel specimen quenching had, of course, a considerable hardening effect; but

the new magnetic condition was only slightly changed when the specimen was brought to the temperature of liquid air.

The work described here was carried out by Professor Gray, Dr James Muir, and the author. We have now obtained a considerable quantity of the alloy in the form of rings and rods. These specimens have been cast for us by Messrs. Steven & Struthers, the well-known Glasgow engineers and brass founders. A continuation of the research is in active progress, and I hope to make a further communication on the subject to the Society at a future date.

On the Development of the Great Axial Lines of Folding in the Highland Schists. By PETER MACNAIR, Curator of the Natural History Collections in Kelvingrove Museum, Joint-Honorary Secretary of the Glasgow Geological Society, and Assistant-Lecturer on Geology and Mineralogy, Glasgow Technical College.

[Read before the Society, 15th November, 1905.]

IN a paper which I contributed to this Society some time ago, I dealt with the general geological structure of the Highlands, and compared the Grampians with such a mountain chain as the Alps, pointing out that though they differ in some striking respects, yet they have a closer structural relationship than appears at first inspection. Thus in the Grampians we have no great dominant ridge of uplift such as we find in the massives of St Gothard and Mont Blanc. The reason of this is that the Grampians being of a much higher antiquity than the Alps, they have been subjected to a much more prolonged period of denudation, so that they are now little more than the mere basal wreck of such a true mountain chain of elevation as the Alps. I further pointed out in that paper that with the appearance of Professor Lapworth's papers upon "The Secret of the Highlands," a new impetus was given to the study of this region, proving, as he did, that the views advanced by Nicol as to the structure of the North-west Highlands were correct, and showing that the structure of that region was not so simple as had hitherto been supposed. In this paper there also appeared an exposition of the principles of mountain structure developed in Heim's "Mechanismus der Gebirgsbildung." No attempt was, however, made to apply these principles to the region under notice, as Professor Lapworth had not examined the ground. He had, however, shown that the Ordovician and Silurian rocks of the Southern Uplands had the same tectonic arrangement as was to be found in mountain chains of elevation, and that a comparatively thin series of strata had been so folded upon themselves as to give the appearance of a very great thickness of rocks, the isoclinal foldings being arranged in a series of anticlinoria and synclinoria. After a somewhat detailed examination of the Highlands, I have come to the conclusion that if these principles be applied to explain the structure of the Grampians, they afford

the most satisfactory solution of the problem that has yet been advanced. In my former paper I pointed out that in the first contribution of the Geological Survey of Scotland towards a solution of the structure of the Grampians, it was somewhat striking to note that instead of following up the classic researches of Heim and Lapworth upon the origin and development of mountain structures, they had advanced a somewhat peculiar and complicated theory to account for the structures seen in the Cowal district. In this district it is assumed that there is a great syncline of strata about fifteen or sixteen miles in width. This syncline is traversed by what is called an anticline of foliation which is supposed to be roughly coincident with the syncline of bedding. At the end of the memoir a horizontal section is given showing the relationship of this original syncline of bedding to the secondary anticline of foliation, and I think that no geologist who examines that section can come to any other conclusion than that it must involve an immense thickness of strata. In the more recently published memoir upon the Geology of Mid-Argyll (explanation of sheet 37) Mr Clough refers as follows to my theory:—"It is also possible that the syncline may not be part of a structure which has been bent by an anticline, but that it may be of the same age as the arches on the north-west side of the flat belt, and that the dominant foliation planes which dip south-east may have been produced by pressure from above acting from a south-east direction. The view that in this locality there is no large anticline even of foliation was first advanced, we believe, by Mr. Peter Macnair. It has the merit of being comparatively simple, and seems to accord well with the structures lately discovered by Mr E. H. Cunningham Craig in the adjoining one inch map 38, where on the east side of Loch Lomond, and near Loch Katrine, various synclines have been found, the south-east limbs of which are in some places vertical, while in others they dip north-west in an opposite direction to the north-west limbs." In a footnote Mr Clough refers to the following statement made by me in the "Building of the Grampians":—"As we approach a line running down the centre of Cowal through the heads of Loch Goil, Loch Striven, Loch Ridden, and the hills to the north-west of Tighnabruaich, we find the axes of the isoclinal folds approaching the vertical." Now when I wrote that paper it certainly did appear to me that the axes of the minor harmonic folds near the centre of the Cowal synclinorium are in an almost vertical position.

At the same time I recognised that in this area the limbs of the major folds must of necessity be comparatively flat, as this is a structure characteristic of a synclinorium, in opposition to an anticlinorium.

Further, Mr Clough refers to this as the crucial point of difference between us; to this I must, however, make a dissent, as I believe that his idea of the development of the Cowal axis of folding is fundamentally different from that of mine, and I have tried to show that the Cowal axis of folding corresponds to what Dana has called a synclinorium, and that it was flanked both on the north-west and south-east by anticlinoria or fan-shaped structures. In the Cowal area we have the south-east and north-west limbs of these structures respectively represented.

In my paper on the "Building of the Grampians," I have shown that there passes down the centre of the Highlands a great axial line of folding having a fan-shaped structure from which the rocks are thrown off towards the north-west and south-east in a series of isoclinal folds. Near the apex of the fan the isoclines are vertical, on each side the axes of the folds dip onwards towards the north-west and south-east respectively. Traced towards the south-east the axes of the folds become flatter and flatter, till they become almost horizontal. On approaching the Highland frontier they again begin to rise, till they dip towards the north-west at a high angle. In following certain lines of section from the apex of the fan towards the south-east, lower and still lower beds rise to the surface. On the apex of the fan we have the Upper Argillaceous Zone, further south the Garnetiferous Schist-Zone, then the Loch Tay Limestone Zone, followed by the Lower Arenaceous Zone and the Lower Argillaceous Zone, best seen along the Highland frontier. On the north-west side of this great axial line of folding the arrangement of the schist zones is somewhat different, as the members of the Lower Arenaceous Zone and Lower Argillaceous Zone seen along the Highland frontier do not appear at the surface, but are everywhere hidden by beds higher in the series and above the Loch Tay Limestone. Undoubtedly the most prominent structural feature in the schists of the Highlands is this great axis of folding which runs diagonally across the south-eastern and south-western Highlands, and which I have named the Ben Lawers Anticlinorium, or fan-shaped structure, because it was first observed in that mountain.

Along this tectonic axis as a centre the schists, as I have

already said, are arranged in vertical folds, this vertical folding being characteristic both of the bedding and subsequent foliation where the latter has been folded. On each side the axes of the folds dip towards the great central axis. This axis generally follows the strike of the schist zones, but it is also seen to cross the outcrops of these zones, as the axis is dependent on folding more than bedding. In the Ben Lawers district, as has already been shown, the Upper Arenaceous Zone occupies the centre of the fan-shaped structure, whereas further west, in the neighbourhood of Loch Awe, the Upper Arenaceous Zone occupies that position.

The exact position of this axis of folding can be fairly accurately determined in tracing it from west to east across the central Highlands. It is seen first of all on the shores of Loch Craignish in the Sound of Jura, from which point it strikes north-eastwards by Kilmelfort, Kilchrennan, and Dalmally, at the head of Loch Awe. In this area the centre of the fan-shaped structure is occupied by the members of the Upper Arenaceous Zone. From Dalmally this axis can be followed up Glen Lochay by Ben Lui, and from thence along the ridge that separates Glen Dochert and Glen Lochay, through Meall Chuirn, Meall na Saone, and Craig Mhor, where it enters Glen Lochay near the falls of Lochay. From this point it strikes along the crest of the ridge that separates the valley of Loch Tay and Glen Lyon, passing through Craig na Challich, Coir Fionn Lairg, Meall nan Tarmachan, Ben Lawers, Meall Garbh, and Meall Gruaidh, entering Loch Tay near Sron Fernan it abuts against the Loch Tay fault at Wester Achtar. On the east side of the Loch Tay fault the axis reappears at White Bridge, and now follows the ridge that divides the valley of the Tay and the Tummel, passing across Ben Leathan Meall Fead and Cammoch Hill, and entering the valley of the Garry about three miles to the north of Pitlochry. From Dalmally to Loch Tay the schist zones forming the axis of folding belong principally to the Upper Argillaceous Zone. From Loch Tay to the valley of the Garry the axis crosses from the Upper Argillaceous Zone on to the Central Highland Quartzites. From the river Garry the axis passes to the south of Ben Vrackie, being still in the quartzite outcrop, and from thence north-eastwards into the Kincardineshire and Aberdeenshire Highlands, where it is much interrupted by the later granite intrusions, reaching the coast line near Banff.

It seems to me that a careful study of the fragment of this ancient mountain chain preserved in the Scottish Highlands points to the conclusion that the great central massive must have risen over what is now the Midland Valley, and that the Ben Lawers anticlinorium was but a subsidiary elevation compared with this great central fächer. The greater part of this massive has, of course, been carried down between the boundary faults which separates the Midland Valley from the Highlands and Southern Uplands, and lies concealed below the mantle of younger palaeozoic rocks which lie between these two boundary faults.

Along the shores of the Firth of Clyde we just catch a glimpse of the northern limb of this massive. I have already pointed out that to the east of Ben Lomond the rocks along the frontier Highlands generally dip to the north-west. Between Loch Ard and Loch Lomond the beds are almost vertical, or the dips vary, while from Luss down into Cowal, Bute, and Arran, the beds dip at high angles towards the south-east.

Between Loch Lomond and Loch Lubnaig the schists are traversed by a series of cross faults which emerge from the great boundary fault. They are of pre-old Red Sandstone Age, and strike north-east and south-west. As a rule the western portion has been displaced towards the south, *e.g.*, the downthrow is to the west. Perhaps the most important of these is the Loch Tay fault, which has been traced from Aberfoyle, by Loch Lubnaig, Loch Earn, and Loch Tay, to Blair Atholl and Glen Tilt. Further west, and running in an almost parallel direction with the Loch Tay fault, there is another line of disruption which has been traced from the Braes of Balquhidder, across the river Dochert near Luib. From this point it crosses the ridge that separates Glen Dochert and Glen Lochay, entering the latter Glen near Corrycharamaig. It ought to be noted that in this part of its course it crosses the Ben Lawers anticlinorium. From Glen Lochay it has been traced north-eastwards to Loch Rannoch and Loch Garry. Still further west another of these dislocations has been traced from the head of Loch Fyne north-eastwards in the direction of Tyndrum, Loch Lyon, and the west end of Loch Rannoch, to Loch Ericht. These larger faults are accompanied by a series of minor dislocations, which run in a roughly parallel direction with the larger faults.

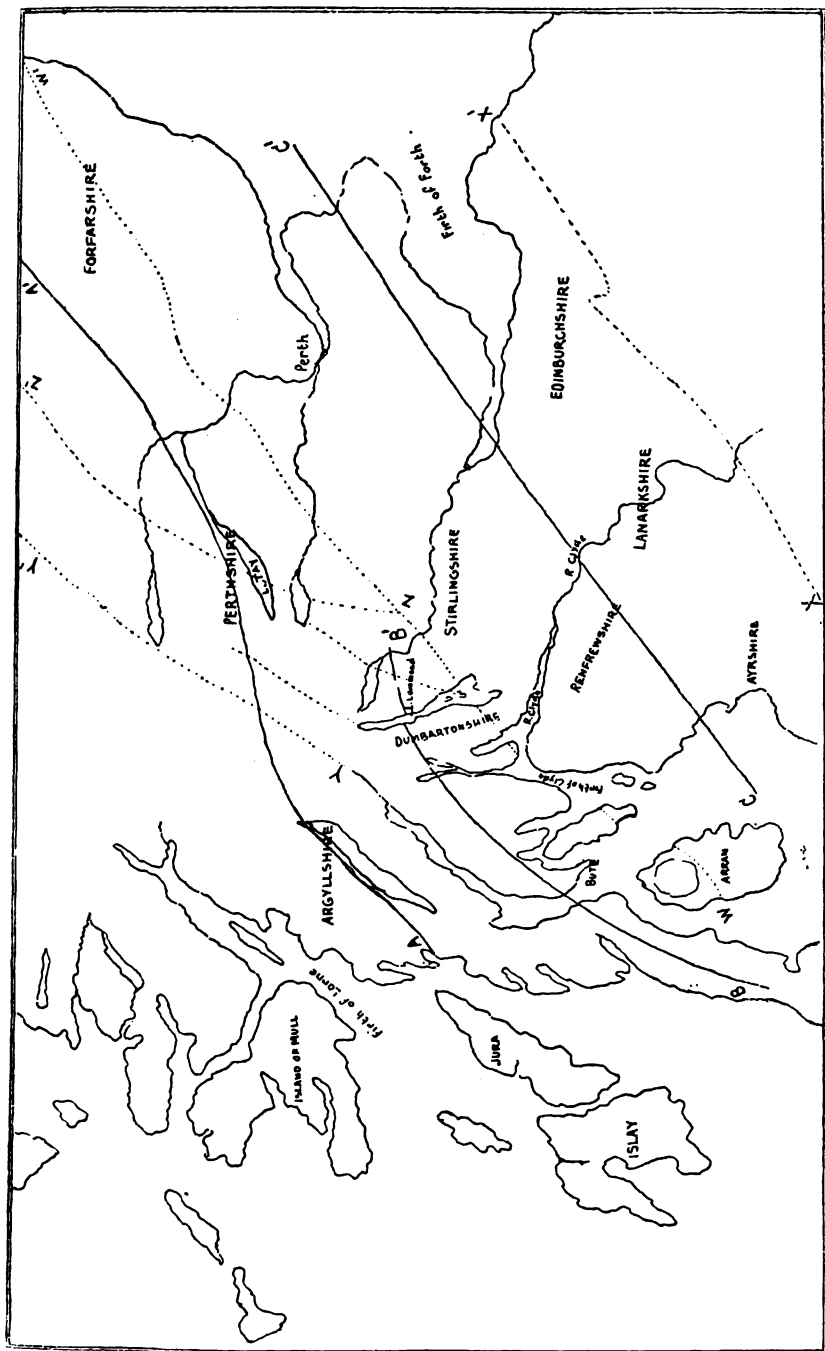
Generally speaking, then, to the east of these lines of dislocation,

and along the frontier Highlands, the beds dip to the north-west, while to the west of them they dip to the south-east. My interpretation of this structure being, that during the ridging up of the Grampian geanticlinal two well defined anticlinoria were developed. The axis of the largest and most important of these running along what is now the centre of the Midland Valley, while the second is seen in the Ben Lawers anticlinorium. Between these two anticlinoria a synclinorium must have been developed, the position of this is shown in the axis of folding that runs down the centre of Cowal.

The axis of the Cowal synclinorium can be traced through the peninsula of Kintyre, from which it crosses to Port a Mhadaidh on Loch Fyne. From this point it can be traced by the heads of Loch Ridden, Loch Striven, Loch Eck, Loch Goil, and Loch Long, terminating on the shores of Loch Lomond at Tarbert. To the east of Loch Lomond the structure of the ground appears to be more complex. This is partly accounted for by the numerous cross faults or lateral wrenches which I have described as occurring in this area, these faults tending to break up and destroy the continuity of the axis of folding, by shifting the outcrops of the schist zones on the west side successively towards the south.

Further, it appears that in the ridging up of these two anticlinoria their axes were driven much closer together towards the west of the mountain chain than they are in the east. An examination of a geological map of Scotland, or even a topographical map, will show this very clearly. Thus the lines of the Southern Upland boundary fault, the Highland boundary fault, the axes of the Cowal synclinorium and the Ben Lawers anticlinorium, the fault which runs along the Great Glen, and the overthrusts of the North-west Highlands, appear to radiate like the spokes of a wheel from a centre situated somewhere in the north of Ireland.

This is made exceedingly clear by the comparison of a section taken across the western part of the chain with one taken across the eastern. Thus such a section as that taken across Cowal and described by me in the "Building of the Grampians," shows that the strata which constitute the Cowal synclinorium have been much more closely compressed, and have suffered a more intense dynamic metamorphism than the strata which occupy a similar tectonic position further to the east have been.



SKETCH MAP TO SHOW THE POSITION OF THE GREAT AXIAL LINES OF FOLDING,
AND THE PRINCIPAL FAULTS.

A¹ Ben Lavers Anticlinorium. B B¹ Cowal Synclinorium. C C¹ Axis of supposed Great Central Massive or Anticlinorium.
W W¹ Highland Boundary Fault. X X¹ Southern Upland Boundary Fault. Y Y¹ Tyndrum Cross Fault. Z Z¹ Loch Tay Cross Fault.

In a word, it seems that when traced from east to west the two anticlinoria have been driven closer and closer together, till in the region of Loch Lomond inversion of the strata, accompanied by the great lateral wrenches, has taken place, and has thus ushered in still further to the west and along the shores of the Firth of Clyde the northern limb of the great central massive.

The experimental researches that have been made in mountain building show that by continued compression of the strata a simple anticline may be made to pass eventually into a fan-shaped structure consisting of a complex series of isoclinal folds. By a continuation of the pressure the underlying and oldest strata are made to come into the core of the fan, and a strong tendency to the development of thrust planes on each side of it takes place. It seems to me that the great central massive that rose over what is now the Midland Valley must have belonged to that type of fan-shaped structure which is produced by intense compression. The evidence derived from the sections exposed along the western shores of the Firth of Clyde shows that the oldest rocks in the Highland series are being gradually brought into the centre of this "fan," and I have come to the conclusion that the two great boundary faults, though now of the nature of normal trough faults, were originally developed along the flanks of the fan-shaped structure by the intense lateral compression to which it was subjected.

It is somewhat interesting to note in this connection that some of the upper Silurian inliers which appear to the north of the boundary fault in Lanarkshire are truncated by reversed faults which hade in a parallel direction with the boundary fault, the northern limb consisting of the oldest strata having been driven over the southern limb of younger strata.

If this view of the structure and development of the Grampians is supported by further investigation, it will bring the tectonics of this fragment of an ancient and extensive mountain chain still more into line with such structures as are seen in the Alps and Himalayas, and will also, I venture to think, help to explain much that is still obscure in our knowledge of the dynamics of the Scottish rocks.

Some Notes on the leaves of Nephrodium Filix Mas. L., and Scolopendrium Vulgare Sm., in relation to Environment. By JANIE HAMILTON M'ILROY, M.A., B.Sc., M.B.

[Read before the Biological Section, 18th January, 1906.]

THE following notes are the outcome of work which might have had larger scope had it not been that, while engaged upon it I became aware of the research of Mr L. A. Boodle on the same subject.¹

Since the publication of his paper upon *Pteris aquilina* has anticipated the main facts, it will suffice to state briefly my own results acquired from genera of Ferns different from his.

In the case of *Nephrodium Filix mas*, I took for examination material which was typical of extreme insolation, and of extreme shade: this was obtained in leaves of two plants grown near together in the open, and under natural conditions. They were taken in the autumn of 1903, and, except for the difference of exposure, were comparable in every way. The points to which I directed my attention were mainly those mentioned by Schimper when speaking of the influence of external conditions in producing xerophilous structure.² Taking the sun-form as the basis for comparison, I expected to find in the shade-form (1) a relative increase of surface area: (2) a shortening of the palisade cells: (3) Increase of the intercellular spaces: (4) Diminution in thickness of cuticle and epidermis: and (5) prominence of the stomata. I shall endeavour to show how far the results bear out these anticipations.

On first inspection the difference between the leaves of two plants is most marked, as will be seen from figs. 1 and 2, which are from photographs. The pinnæ of the exposed plant were small, and leathery in texture, whilst those of the shade-form were large, delicate, and almost translucent. The leaf of the sun-form was thickly studded over its whole extent with sori, whilst in the shade-

¹ "The structure of the leaves of the Bracken (*Pteris aquilina*, Linn.) in relation to environment."—Journ. Linn. Soc. Bot., vol. xxxv. (1904), p. 659.

² Plant Geography, Eng. Edn., 1903, p. 4, etc.

form many pinnæ were infertile, and those which bore sori at all had them over only a small area. The character of the indusia also differed: those of the exposed plant being small and shrivelled, those of the shade-form larger, thin, and smooth.

An estimate of the relative spore-production of average leaves of the two plants led to the recognition of a substantial difference in output. The average number of sori per pinnule in the sun-form was 8, and in the shade-form 5. The sporangia averaged 213 per sorus in the sun form, and 206 in the shade form. The average number of spores per sporangium was 59.25 in the sun-form, and 54.5 in the shade-form. From this the average spore-

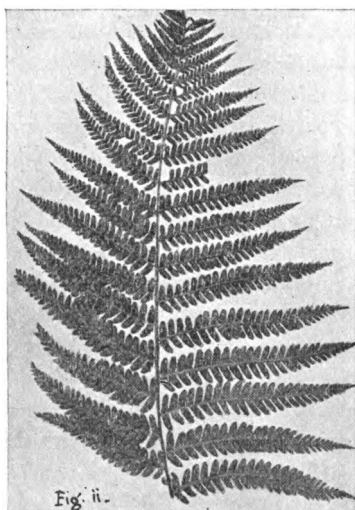
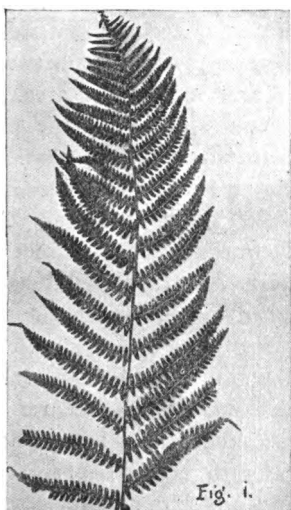


Fig. i.—Specimen of *Nephrodium* grown in the open under conditions of extreme exposure to sun and wind.

Fig. ii.—Specimen of *Nephrodium* grown in the open under conditions of extreme shade. From photographs.

output per pinnule comes out as 100,962 for the sun-form, and 56,135 in the shade-form. Thus, in those pinnæ which are fertile at all, the ratio of fertility per pinnule of the sun-form to the shade form comes out practically as 2:1. As the average number of pinnules per pinna in the two forms is as 41:27.6, and the number of fertile pinnæ also larger in the sun-form than in the shade form, it is clear that the fertility of the former is very far in advance of the latter.

A comparison of the extent of the leaf surface was made by tracing the outline of the pinna on paper of uniform thickness, and weighing these areas after they were cut out. Out of a large number of cases the average came out as 138 for the sun-form, and 275 for the shade-form: in other words, the shade-form was practically double the area of the sun-form.

The relative thickness of the leaves was compared in sections of corresponding parts of leaves of each type: out of many instances the average proportion of sun-form to shade form came out as 1:1.17. It must be borne in mind that, though this brings out the thickness of the leaf of the sun-form as slightly less than that of the shade form, these leaves were both developed in the open,—a condition very different from that of a closed, saturated atmosphere. It is obvious that there is no proportion between the thickness of the shade-form leaf and the greater area, as compared with that of the sun-form.

It has been seen that there is reason to expect a greater area of intercellular spaces in proportion to the area of cellular tissue as seen in section in the shade-form than in the sun-form. An estimate of the proportion was made by tracings of the leaf-section on uniformly thick paper, under the *camera lucida*: the cellular and intercellular areas thus accurately mapped out were then cut out and weighed. From a number of typical instances the ratio of intercellular space-area to area of leaf-section came out as 1:3.62 for the sun-form, whilst that in the shade-form was 1:2.67. Expressed roughly in words, this gave the intercellular space-area in the sun-form as nearly one-fourth of the leaf-section, whereas in the shade form it was nearly one-third: there is thus a larger proportion of intercellular space-area in the shade form.

Examination of the character and disposal of the stomata led to no pronounced result. The number of stomata per unit area was rather smaller in the sun-form than in the shade. In surface view the stomata in the sun-form appear slightly more circular in outline, and have thicker walls than is the case in the shade-form, where they are oblong and thin-walled (figs. 3, 4). In vertical section no marked difference in the degree of prominence of the guard-cells was observable.

From the point of view of rigidity, it was expected that the sclerenchyma of the sun-form would be more developed than in the shade-form, and out of various measurements the amount came out slightly in excess (figs. 5, 6). Investigation of the

structure of the mesophyll was made, having in view the differences described for other plants by various authors, notably Stahl,¹ and Wiesner.² But in *Nephrodium* the assimilating tissue is at best of a poorly differentiated type, and it was almost impossible to arrive at any definite estimate regarding the balance of spongy tissue to palisade. There was no suggestion of any hypodermal layer in the leaf-wing, but the hypodermal tissue in the region of the midrib was found to be more extensive in the sun-form than in the shade-form. This was seen both in its extension laterally in the wings of the pinnule, and also in the depth of the band in the cortex of the midrib itself. From figs. 7, 8, which are selected as being typical of each plant, it is seen that the intercellular spaces in the shade-form are on the whole larger, and extend upwards rather more towards the epidermis than is the case in the sun-form. This gives the upper mesophyll of the shade-form a slightly more spongy character than that of the sun-form. But in the latter, although the cells of the upper mesophyll are still very irregular in shape, and do not show any elongation vertically, they are rather more closely fitted together than those of the shade-form, *i.e.*, they approach palisade type. It will be seen that these figures confirm the quantitative estimate of the intercellular spaces given above.

In comparing these two leaf-types, however, it must be remembered that the shade-form was grown in the open, and not in a confined or saturated atmosphere, otherwise the contrast might have been more marked.

Scolopendrium vulgare. Sm.

The following notes are based upon observations made on material which was put under experimental conditions in 1900. The leaves were taken from plants which had been brought from natural open-air conditions, and transferred to the Filmy Fern House of the Edinburgh Botanic Garden. This house is fitted with closed, glazed cases, and has a northern aspect. The atmosphere is constantly about the point of saturation with moisture, and direct sunlight never reaches it. The difference of condition

¹ "Ueber den Einfluss des Sonnigen oder schattigen Standortes auf die Ausbildung der Laub-blätter."—Jenaische Zeitschrift, xvi. 1883.

² "Formänderungen von Pflanzen bei Cultur im absolut feuchten Raume und im Dunkeln."—Ber. d. D. Bot. Gesellsch., Bd. ix. 1891.

between Ferns grown in the open and those within is therefore much more marked than in the case of the *Nephrodium* described above.

A comparison was made of the leaves thus matured in the open with those grown in the closed cases ; the result was as follows :— The external appearance of the leaf was in each case typical of its habitat : the exposed leaf was thick, and of a leathery consistence, while the protected leaf was thin, translucent, and almost filmy in texture. The fertility of the protected leaf appeared to be deficient as compared with that of the exposed leaf, but no detailed estimates were made, so as to put this into numbers.

Sections were made from comparable portions of the two leaf-types, and figs. 9 and 10 were selected as typical of each. It is seen from these that the internal structure of the leaves differs : the protected form showing a larger proportion of intercellular spaces to cellular tissue than in the exposed form, but actual quantitative estimates were not made, as in *Nephrodium*. With regard to the stomata, the average number per unit area, out of a large number of cases, gives a slightly larger number for the exposed form. The structure of the stomata does not offer any marked difference in the two forms, except that in all cases the cell-walls are thicker in the exposed than in the protected form. The difference in thickness of leaf of the two types is very pronounced ; the average of a number of measurements showed the ratio of the exposed to the protected type as 7.2 to 6.06. The structure of the leaf is thus in every way more or less in keeping with the external appearances, though some slight allowance may perhaps be made for differences of age. In any case the development of the leaves under the artificial conditions seems to have been considerably restricted, both with regard to leaf-thickness as also leaf-area, and spore-production.

During the summer of 1903 a number of experiments were started on plants of *Scolopendrium* taken from natural conditions in the open. In them exposure to shade, and to an atmosphere approaching saturation led to similar results as regards texture, but the leaf-area was not restricted as in the Edinburgh plants, but rather increased. Such divergent results are probably the outcome in some measure of differences of nutrition of the plants before the experiments began.

The object with which these observations were started was to

PLATE III.

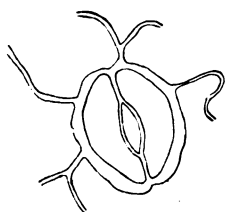


Fig. 3.

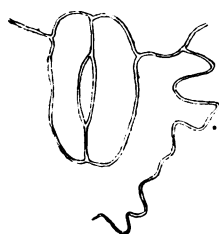


Fig. 4.

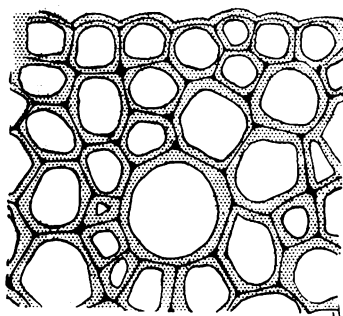


Fig. 5.

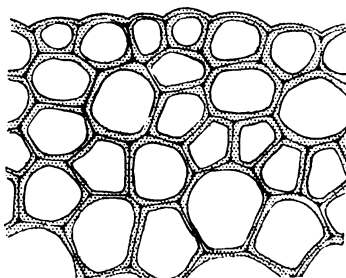


Fig. 6.



Fig. 7.



Fig. 8.

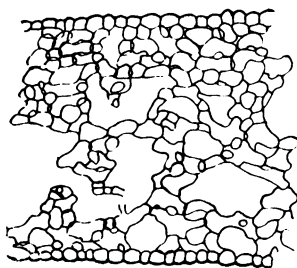


Fig. 9.

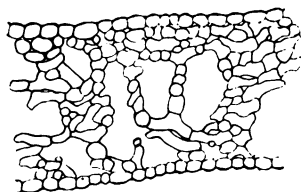


Fig. 10.

see how far in Ferns the structure of the leaf is liable to be modified in the direction of the filmy character, by conditions of moisture and shade. The results, so far as they go, are not more marked than those which may be obtained by similar experiments on Phanerogamic plants. Perhaps, however, the Ferns selected were not endowed with as high a degree of plasticity as some others; in the most exposed forms they still retain their hygrophilous character, while in the converse case the filmy character is not actually approached. But in *Pteris aquilina* Mr Boodle has found a plant whose plasticity offers results more clear and convincing. He finds that in dry, exposed conditions the leaves are xerophytic to a very marked extent, having a well defined hypoderm, and palisade tissue. The contrast comes out in the shade-form, in which there is no hypoderm, and little or no palisade. It is also seen in the readiness with which the leaves of the same plant respond to the altered conditions. It would appear, from a comparison of the results, that all Ferns do not react alike to changes of external condition, and that *Pteris* shows a wider and more ready range of plasticity than *Nephrodium* or *Scolopendrium*.

I should like to express my great indebtedness to Professor Bower for his kind help and supervision during the time I worked with him in the Botanical Department of the University of Glasgow.

DESCRIPTION OF DIAGRAMS.

Fig. iii.—Drawing, under camera lucida, of stomata on under surface of leaf of sun-form of *Nephrodium*.

Fig. iv.—Ditto of shade form.

Fig. v.—Tracing under-camera lucida of the sclerenchymal cells at midrib in the sun form of *Nephrodium*.

Fig. vi.—Ditto of shade form

Fig. vii.—Drawing under camera lucida of the transverse section of leaf of *Nephrodium* grown in exposed situation.

Fig. viii.—Ditto of shade form.

Fig. ix.—Drawing under camera lucida of sun-form leaf of *Scolopendrium*.

Fig. x.—Ditto of shade form.

In all the drawings, the conditions under which comparisons were made were exactly the same with regard to portion of leaf chosen, and microscopic magnification.

*Some early Grammars and other School Books in use in Scotland
more particularly those printed at or relating to Glasgow.*

By DAVID MURRAY, M.A., LL.D.

PART SECOND.

[Read before the Historical and Philological Section, 7th March, 1906.]

BEFORE resuming the description of Latin Grammars published at Glasgow, it will be desirable to refer to the position of the Glasgow press. In 1638, George Anderson, printer in Edinburgh, set up a press in Glasgow, apparently at the request of the Magistrates, as they assigned him an annual salary and repaid him the expense he had disbursed in removing his plant to Glasgow.¹ He died in 1648,² and Glasgow was without a printer for the succeeding ten years. Attempts seem, however, to have been made to obtain one, as Robert Baillie, who was then Professor of Divinity, writing in 1651, says, "If Duncan Munne had kept his gift of printing, we had gotten a presse long ere now; its a very great pitie that a presse in any terms should be wanting."³ In the years 1654 and 1655 Andrew Anderson, son of the former printer, carried on printing in Edinburgh, and in 1657, on the invitation of the Town Council, agreed to remove to Glasgow.⁴ In 1658, he printed Sylvester Rattray's *Aditus novus ad occultas Sympathiae et Antipathiae causas inveniendas*, the title-page bearing simply "Glasgae, Excudebat Andreas Anderson, Anno Dom. 1658." In the course of that year he obtained the appointment of University printer as well as that of Town's printer. In 1659, he printed the graduation Theses on which his name appears as

¹ Minute of the Town Council, 4th January, 1640.

² His heirs issued one or two books which had probably been set up at the time of his death, e.g., *The Psalmes of David in Meeter: with the trose interlined.* By Mr. Zachary Boyd, Preacher of God's Word. . . . Printed at Glasgow, by the Heires of George Anderson, Anno 1648. Title within an ornamental border; 12mo, unpagged. Signatures A1-27; Zachary Boyd's *The Songs of the Old and New Testament in Meeter*, bears the same imprint and the same year.

³ *Letters and Journals of Robert Baillie*, iii. p. 134. Edinburgh, 1842. 4to.

⁴ Minute of Town Council, 22nd July, 1657.

"Urbis et Academiae Typographus," and in 1660 he reprinted *A Declaration of the Generall Convention of Yreland*, styling himself "printer to the Toun and College." Baillie, who was something of a connoisseur in the matter of typography, had no great opinion of his work. "The Latine that is printed either here or at London, is so exceedingly ill done, that I will be very loath, if I can otherwayes doe, ever to employ them either for myself or others."¹ Anderson returned to Edinburgh in 1661,² and was succeeded in that year by Robert Sanders,³ who was then carrying on business as a bookseller in Glasgow. His name is found as printer on a title-page dated 1656, but this is probably a misprint.⁴ He obtained the appointment of printer to the Town of Glasgow, and, for a short time at least, of printer to the University.

Shortly after his return to Edinburgh, Anderson contrived to obtain the appointment of printer to the City and College of Edinburgh, and in 1670 issued an edition of the New Testament "with so many gross errors and faults" that its circulation was prohibited by the Privy Council.⁵ Notwithstanding this he insinuated himself so much into the good graces of the directors of public affairs that "for payment of a composition in Exchequer and other weighty reasons," he, on 12th May 1671, obtained a gift under the Great Seal appointing him the King's only

¹ Letter, 11th November, 1658; *Letters and Journals*, iii. p. 382, cf. *Ib.*, p. 449. He ultimately sent his *Opus Historicum et Chronologicum*, which he had then on hand, to be printed in Holland. It was published at Amsterdam in 1663, and a second edition appeared in 1668. See *Ib.*, pp. 478, 483.

² The Town Council of Glasgow, on 8th May, 1661, instructed the treasurer to pay him 50 merks to help to transport his goods to Edinburgh.

³ Minute of Town Council, 23rd September, 1661. On 20th April of the same year he was paid £20 Scots "for prenting of the preaching was preached be Mr. Hugh Blair before the Parliament," a copy of which, formerly in the library of David Laing, is now in the British Museum.

This preaching, it should be mentioned, was a sermon in favour of the alterations in church government and worship proposed after the Restoration. Mr. Hugh Blair was one of the "time-servers" and "sycophants" employed to promote the views of the Court party; and was one of the three clergymen, in the Presbytery of Glasgow, who conformed to the new order of things. On 14th September preceding, i.e. 1660, John Graham, provost, and John Spreul, town-clerk of Glasgow, who had been reckoned favourers of the *remonstrance*, were imprisoned in Edinburgh Tolbooth. Brown, *History of Glasgow*, i. pp. 131, 132, 141, Glasgow, 1795, 8vo. Baillie, *Letters*, iii. p. 448. In 1662, the "drunken Parliament"—a meeting of the Privy Council—sat at Glasgow.

⁴ *The Works of the famous and worthy Knight Sir David Lindsay of the Mount*. . . . Glasgow. Printed by Robert Sanders, one of His Majesty's Printers, 1656. The figures are plain. I write from a copy in my own possession. In a Glasgow Sale Catalogue of 1712, No. 354, the same date is given.

⁵ Lee, *Memorial for the Bible Societies*, p. 116.

principal printer for forty-one years. This gift was ratified by Parliament next year,¹ and gave him the exclusive right of printing Acts of Parliament, Bibles, all books of theology, commentaries, concordances, books of the common and civil law, school authors, Grammars, Rudiments, Psalms, Confessions of Faith, Larger and Shorter Catechisms, Kalendars, &c. By this gift, says James Watson, "the art of printing in this Kingdom got a dead stroke ; for by it no printer could print anything from a Bible to a Ballad without Mr. Anderson's licence."²

When the Signature was passing through Exchequer the other printers in Scotland became alarmed and objected to it. Anderson thereupon made terms with George Swinton, James Glen, Thomas Broune and David Trench, booksellers in Edinburgh, and undertook to make them partners in the gift and so induced them to agree to withdraw their objections. This they did without communicating with the other objectors,—Robert Broune, James Miller, John Menson, Gideon Shaw and John Cairnes, stationers and booksellers in Edinburgh, and Robert Sanders, stationer and bookseller in Glasgow—and so the gift passed.

No sooner was the gift complete than Anderson, accompanied by Swinton, Glen, Thomas Broune and Trench, "proceeded to Glasgow and in a disorderlie manner" came to Sanders' printing office, and by threats and promises induced his journeymen and apprentices to desert their work, and to return with them to Edinburgh. The matter was then brought before the Privy Council, who, on 21st December, 1671, decided that the King's gift ought to be restricted, and that Anderson had the privilege of printing Acts of Parliament and Proclamations, Bibles (except the New Testament and Psalm book in Roman type) ; and further—Anderson having so far given way and consented—that Robert Sanders or any other printer in the Kingdom had full liberty to print the New Testament in Roman or any other type about the same size. It was, however, declared that the King's printer had the only privilege of printing the Confession of Faith, Larger and Shorter Catechisms and all books of Divinity and School books enjoined, or that should be enjoined, to be read in churches or taught in schools by public authority. Anderson immediately represented that this arrangement rendered

¹ *Acts of the Parliament of Scotland*, ed. Thomson, viii. p. 206.

² *History of the Art of Printing*, p. 12, Edinburgh, 1713, 8vo.

his gift to a large extent nugatory, seeing that in fact there were no books of Divinity enjoined to be read in churches or school books enjoined to be taught in schools. The Privy Council, accordingly, on 16th September, 1672, confirmed their former decret "with this alteration and amendment, 'That the said Robert Saunders or any other printer shall have the privilege of printing the New Testament and Psalme Book in the foresaid letter commonly called English Roman, printed by the said George Swintoun and James Glen in the year 1669, bot in no other syse or letter, and farder, that, with Anderson's consent, the said Robert Sanders or any other printer in this Kingdome shall have also full liberty to print the haill books after specifcit as the King's printer himself.'" These were:—

Virgil, with or without notes.	Claudian.
Sallust.	Tacitus.
Horace.	Textoris Epistolae.
Quintus Curtius.	Tallei Rhetorica.
Dialogi Sacrorum.	Vossii Rhetorica.
Orationes Ciceronis.	Rami Dialectica.
Erasmi Colloquia Majora.	Vrsini Catechismus.
Ciceronis Epistolae.	Aesopi Fabulae.
Erasmi Colloquia Minora.	Thomasii Dictionarium.
Joannes Lodovicus Vives.	Sylva Synonimorum.
Bellum Grammaticale.	Justini Historia.
Janua Linguarum.	Burgersdicii Logica.
Smetii Prosodia.	Livy's Orationes.
Buchanani Prosodia.	Greek New Testaments.
Juvenal and Persius.	Senecae Tragediae.
Lucan.	Poetae Minores.
Terence.	Homer's Iliades.
Cæsar's Commentaries.	Kempis de Imitatione Christi &
Lucius Florus.	Plautus Comedies.
Carmina Proverbialia.	

The decret further declared that Anderson and his co-partners "shall have the sole and only privilege of printing of all books of divinity and school books used and accustomed to be read in churches and taught in schools, except the school books foresaids which the King's printer hath consented that any other printer may have also full liberty to print as he himself."¹

¹ *Registrum Secreti Concilii*, Decreta, 16th September, 1672. See also *Registrum Secreti Concilii*, Acta, 16th September, 1672.

Anderson died in 1676, and the gift passed to his son James as his heir,¹ but as the latter was a minor, the management fell to the widow and executrix Agnes Campbell. She was a woman of energy. She paid out all the partners save one, George Swinton, and then took proceedings against the remaining printers in Scotland. She brought an action, in name of her son and with the consent of the Lord Advocate, as representing the Crown, against Robert Sanders. The libel was in due course referred to his oath, but he declined to depone, and, in consequence, the Privy Council, on 6th March, 1677, held him as confessed and committed him prisoner to the Tolbooth of Edinburgh until further order, and ordained him to obtemper the Act of the Privy Council of 16th September, 1672, in all points. He was liberated in the course of a few weeks, and returned to Glasgow, where he again commenced to print; and between April 1677 and February 1680 he printed and published:—

Catechismes.

Durhame on the Revelation.

Dyer's Works.

Vincent on Judgement.

Vincent's Catechisme.

Broun's Pathway to Heaven.

Durhame on the Commands.

Flavell's Sainct Indeed.

Grammars.

Rudiments and Vocables.

New Testaments and Psalme Books in other type than
that specified in the Act of 16th September, 1672.

Confessions of Faith.

Rhetorica.

Mr. Brierlie.²

Mr. Graye's Twenty-Sevene Sermons.

¹ See Chalmers, *Life of Ruddiman*, p. 209, who states that the succession to this gift shows that printing materials were heritable not moveable. This is hardly correct. What was treated as heritable was the gift, and it was so, no doubt, on the ground that it was a right having a *tractus futuri temporis*.

² I do not know the reference. John Brierly or Brerely was a pseudonym of Laurence Anderton, S.J. (1575-6-1643), the author of *The Protestant's Apologie*, 1604, 4to; *Sainct Austine's Religion*, 1620, 8vo, and other works. It is unlikely that any of these would be reprinted in Glasgow. It is possible that the work referred to may have been a reply to Mr. Brierly, but if so, why it should appear as late as 1677 it is difficult to say, as the original works were out of date by that time.

¶The Whole Duty of Man.

Doelittle on the Sacrament.

With several Books of Divinitie and Schoole Books.

These, it was held, he was precluded from printing, in virtue of the arrangement of 1672; and that he had "directly contravened the tenor of His Majesties said gift and act and decreet of Privy Council foresaid in high and proud contempt of same." Decree was accordingly pronounced against him in absence.

Sanders had in fact printed two editions of the Confession of Faith, one in 1669 in 18mo, and the other in 1675 in 4to. A copy of the latter was for many years used in the Presbytery of Dundee, and if it was not authentic, a long series of ministers and elders had subscribed, as a standard, a book which was not a genuine one.¹

Sanders took steps to be reponed against this decree, and appeared personally when the case again came before the Privy Council upon the 16th February, 1680. It was then decided first that the Lord Register, who had intervened, had right to print Acts of Parliament, and next that His Majesty's printer had the sole privilege of supervising the press and of printing the Proclamations of State, Bibles and all other books except those granted in the concessions made by Andrew Anderson, and mentioned in the Act of Privy Council of 16th September, 1672. Sanders admitted that he had imported and sold Bibles, printed in Holland, and had reprinted and sold several books of divinity. He was prohibited from doing the like in the future.

The list of books conceded to Sanders in 1672 is an interesting one. Some of them were no doubt ordinary school and college books, but it is a question whether the greater number were in general use or were even used at all in Scotland. Many of them were certainly not printed either by Sanders or the King's printer or by any printer in Scotland.

After this prosecution Sanders purchased George Swinton's share of the gift, and assumed the title of one of the Sovereign's printers. He brought workmen and materials from Holland and printed several books very well.² The persecution to which

¹ Lee, *Additional Memorial*, p. 85, and see pp. 108, 133.

² Watson, *History of Printing*, p. 13. About the same time John Cairns, bookseller in Edinburgh, having set up as a printer, brought Joshua Van Solingen and Ian Colmar from Holland to assist him, and Cairns dying in a short time, they acquired the printing house. *Ib.* p. 14. The Society of

Sanders was subjected by the King's printer explains his various descriptions upon his title-pages—"Printer to the Town," "Printer to the Town and College," "One of His Majesty's printers." He died about 1696, and was succeeded by his son of the same name, generally known as Robert Sanders of Auldhouse.

Before passing from the subject of printing it may be mentioned that in 1662 Mr. John Andersoone, "one of the doctouris of the Grammer Schoole," had an allowance from the Town Council "for dedicating a book to the magistratis."¹ What the book was it is impossible to say, as no copy has been preserved, so far as I am aware, but presumably it would be printed by Sanders. John Anderson was the author of many occasional Latin poems² and in 1655 had the sum of £4 "for wrytting of Programmes to the Colledge."³ He had formerly been schoolmaster in Govan, and was appointed Upper doctor in the Grammar School on 26th June, 1649.⁴

Stationers had also, about 1687, some very good foreign workmen. They sold off their shares to George Mosman, one of their number, who retained the workmen. *Ib.* p. 17. See also *Ib.* pp. 21, 22.

One of Sanders' Dutch workmen, before coming to Glasgow, "fell asleep in the ordinary time of night for sleeping, and slept thirty days and nights." *Law's Memorials*, p. 223, Edinburgh, 1828, 4to.

¹ Minute of Town Council, 22nd March, 1662. On 1st October, James Cors, philomath, "a native of Glasgow," had ten dollars "for dedicating his almanak to the town."

² See *Supra*, Part i. p. 21. Prefixed to Sylvester Rattray's *Aditus novus*, *supra*, p. 3, there is "In Auctorem & Opus Encomiasticon," signed I. A., which is no doubt John Anderson.

See also Ninian Paterson's *Epigrammata*, p. 3, Lib. 2, Epig. 24, 42; Bell, *Roma Restituta*, pp. 19, 294, Glasgow, 1672, 12mo; George Sinclair, *Ars nova et magna Gravitatis et Levitatis*. Roterod., 1669, 4to. A Joannes Andersonus entered the University of Glasgow in 1636 (*Munimenta Universitatis Glasguensis*, iii. p. 90), and was laureated in 1639. *Ib.*, iii. p. 23, but while this was probably the schoolmaster, it is impossible to establish the identity.

³ *Munimenta Universitatis Glasguensis*, iii. p. 578. A programme, in its academical sense, was a written or printed notice affixed to the doors or walls of the College announcing University Solemnities and Functions, such as Speeches, Disputations, Funerals, and the like. In October, 1700, there being a vacancy of a Profession of Philosophy in the College of Edinburgh, the Town Council "appoint a public dispute to be made in the said College for the said office. In order thereunto they ordain programmes in the ordinary form to be affixed upon the College, public places and avenues to this city, and other Colleges and Universities of this kingdom, inviting all qualified persons to come and list themselves against the 12th of November next, in order to dispute for the said office."

⁴ Town Council Minute of that date.

Returning now to Latin Grammars printed at Glasgow, the next to be mentioned is:—

5. Ioan. Despauterii Ninivitæ Grammaticæ Institutionis Lib. VII.
Docte & concinne in compendium redacti à Sebastiano
Duisburgensi. Ad prototypum collati, & aucti in usum
studiosæ Juventutis *Multò quam antea castigatiores.*

[Arms of Glasgow.]

Glasguæ, Excudebat Robertus Sanders, Civitatis & Universitatis
Typographus, 1672,

A-F6, 132 pp.¹

This is a Glasgow edition of the school version of Despauter's *Grammar*, by Sebastian Novimola or Niewmeulen, already referred to.² It was the book in general use in Scottish Schools as an advanced grammar, just as the Dunbar *Rudiments* held the first place as an introductory manual.

The work consists of three parts with separate title-pages. The first title page is the above, and serves as the general title.

The next is:—

- Joan. Despauterii Syntaxis . . . Accessit & Erasmi Roterodami de ratione studii Paraenesis. Editio novissima.

Glasguæ, Excudebat Robertus Sanders, Civitatis Typographus
M.DC.LXXII. 8vo. A-D11, pp. 94.

The third part is:—

- Joan. Despauterii Ninivitæ Artis Versificatoriæ Compendium . . . Editio novissima.

Glasguæ, Excudebat Robertus Sanders, Civitatis & Universitatis
Typographus, M.DC.LXXII.

These three parts are similarly printed with separate title pages in all the Scottish editions and correspond with the second, third and fourth parts of Despauter's original work.

Despauter's *Commentarii Grammatici* (Parisiis, Ex Officina Roberti Stephani, 1537)³ is a dumpy folio of 692 pages, with

¹ There is a copy in the Library of the University of Glasgow.

² Part i., p. 4.

³ The colophon bears "Excudebat Robertus Stephanus, Parisiis, Ann. M.D.XXXVIII., XVIIIII. Cal. April. "It is," says David Clement, *Bibliothèque Curieuse* p. 407, "édition fort-rare." There is a copy in the Glasgow University Library, bearing the inscription, "Liber diue Virginis in Deir," that is the Abbey of Deir, St. Mary's, Buchan.

Buisson gives a long list of editions of Despauter's works, *Répertoire des ouvrages pédagogiques du xvi^e siècle*, p. 201, in *Mémoires et Documents scolaires publiés par le Musée pédagogique*, Fasc. No. 3, Paris, 1886, 8vo.

61 pages further of Index in five columns to the page,¹ and one page of *errata*. It contains 9 parts or separate treatises. 1, Rudimenta; 2, Prima Pars; 3, Syntaxis; 4, Ars versificatoria; 5, De accentibus; 6, De carminum generibus; 7, De figuris; 8, Ars Epistolica; 9, Orthographia.

The *Rudimenta* consists of three parts. The first is a condensed view of the parts of speech—in fact a mere skeleton—by way of question and answer. The second contains the more common rules of Latinity, also in the form of question and answer. The third part is a somewhat more extended view of grammar. The treatise concludes with a short Catechism on penance, the Creed divided into articles and the ten Commandments in hexameter verse.

In the preface to this part the author mentions that he had not given the vernacular renderings of any words, as he left this to the teacher, seeing that his book was intended not only for Flemings, but also for Frenchmen, Spaniards, Englishmen, and others.

The exposition is by means of question and answer, a practice which had been in use for many centuries and continued until recent times.² Ruddiman's *Rudiments*, for long the standard grammar in our schools, preserves the old method. Thus the sentences,

“Partes Orationis quot sunt? Octo, Quae? Nomen, pronomen, verbum, adverbium, participium, conjunctio, praepositio, interjectio.”³

¹ Such Indexes were a feature of the time. The Greek Grammar of Nicolas Clenardus, *Institutiones ac Meditationes in Graecam linguam*, Paris, 1572, 4to, with considerably less matter than the *Commentarii Grammatici*, has 95 pages of Index with 4 columns to the page.

² The *Rudimenta Grammaticae Latinae* of Ramus, Paris, 1565, 8vo, are by question and answer; Samuel Iloadly wrote *The Accidence in Questions and Answers*, London, 1683, 8vo; again 1694, and 1737, 8vo.

³ *Methodus Grammatices Donato auctore* p. 1, Argentinae, 1522, 8vo; Lugduni, 1536, 8vo; Magdeburgae, 1547, 8vo. There were very many earlier and several later editions. The *Donatus Minor* also forms a part of a collection of grammatical treatises under the title *Vade Mecum*, Basilee (Michael Furter) 1508, 12mo.

The *Vade Mecum* is a small volume in gothic type, A-T8 in 8s. Its full title is, *Tres partes Alexandri. Tractatus de compositione versuum. Donatus Minor. Regula Remigii. Regule grammaticales. Constructiones cum regiminibus. Et paruulus logice. Alias vade mecum. A Vademecum* is referred to in the *Epistolae Obscurorum virorum*, Book ii., 23 and 46. Böcking, says, vol. ii., p. 493, that he cannot trace the book alluded to under this title. I think it is probable that it is the above. It does not contain the derivation of the word *Magister* mentioned in Epist. 23, but all that was probably intended was to give an absurd etymology, and to suggest the *Vademecum* as an authority. The *Regula Remigii* which forms part of

appear in *Donatus Minor*¹ in Despauter, and in Ruddiman.

Many of the answers are explicit and simple, *e.g.* :—

“Albus, quale nomen? Adiectivum, Quare? Quia non potest per se stare cum verbo in sensu perfecto; vt Albus currit, non dicitur; sed Albus equus currit.”

But many others are not explanations at all; and some are too metaphysical. In discussing the question whether a Latin grammar should be written in Latin or in English, Ruddiman points out that many of the ideas involved are, without verbal explanation, far beyond the understanding of a boy and that consequently it was just as intelligible to make him speak of *nomen* as of noun.²

A great defect of the *Rudimenta* and of most grammars of the time was the want of paradigms. We are informed that there are five declensions, and are told how to decline *poeta*, but no example is given of a noun of any other declension. The case changes are not arranged in columns as in our grammars, but are printed continuously, *e.g.*, “Nominativus, Hic poeta, genitivus, Huius poetæ,” and so on.

While we, nowadays, would consider this difficult, it was still more so to follow *Donatus minor*, *e.g.* :—

“Prima declinatio quot literas terminales habet? Duas. Quas? a et s. Quot terminationes? Tres. Quas? a, as, es. Da exemplum, A vt poeta; as ut Eneas: es, vt Enchises. Que est agnitio prime declinationis? Hec est, cuius genitivus et dativus singulares et nominativus et vocativus plurales in a diphthongon desinunt; accusativus in am correptam; vocativus similis est nominativo; ablativus in a productam; genitivus pluralis in arum correptam; dativus et ablativus in is productam; accusativus in as productam.”³

the *Vademecum* contains many such etymologies, *e.g.*, “Unde dicitur genus? a generando vel a ge Grece quod est terra Latine.” I write from a copy in my own possession. It is not noticed by Panzer, or by Heckethorn.

¹ *Donatus Minor* was an abridgment for the use of schools of the second part of *Donatus*. The original was in plain narrative form, which, in the *Minor* was converted into the form of question and answer. Both the original work and the *Minor* were amongst the earliest books which were printed and passed through very numerous editions, which are a puzzle to bibliographers.

² *A Dissertation upon the way of teaching the Latin Tongue* p. 39, Edinburgh, 1733, 8vo. See Part i., p. 15.

³ When a verse of a poem was quoted it was printed continuously in all the older books, and not in separate lines as we now do. School books were intended to be read aloud and commented on by the master, and the pupils learned by the ear rather than by the eye, so that the style of printing was of less importance than now.

Paradigms are to be found in several early grammars, particularly those of an elementary character; but their use was far from being universal. In an Oxford Latin Grammar, printed by Theodore Rood about 1481,¹ the declensions are given, as in *Donatus minor*,² in narrative form:—"Thys nowne domus ys thus declynde, nominatiuo hec domus genitiuo huius domi vel domus datiuo huic domui accusatiuo hanc domum vocatiuo o domus ablatiuo ab hac domo"; and so on in the plural.³ Despauter, in the third part of his *Rudimenta*, gives⁴ the comparison of adjectives and their case changes in continuous horizontal lines. The information wanted is there, but the manner of communicating it is clumsy.

Joannes Sulpicius, Verulanus, that is of Veroli in Campania, a humanist, and one of the earliest critics of Alexander, published an improved grammar containing metrical rules but no paradigms.⁵ Jacob Heinrichmann, also a humanist and an eminent lawyer, followed with another grammar,⁶ and it, too, was without paradigms. Joannes Aventinus, otherwise Johann Thurnmaier, of Abensberg, on the Danube (1477-1537), a Bavarian chronicler and grammarian, was the author of a grammar⁷ which passed through several editions. It was intended as an introductory work, and the explanations are simplified by being broken up and widely

¹ The only known fragment, consisting of two leaves, is in the British Museum (IA, 55313). See J. H. Hessels in the *Athenæum*, 4th November, 1871; William Blades, *Ib.*, 11th November, 1871.

² Thus Nominatiuo Haec musa, Genitiuo, Huius musae, and so on. Verbs are similarly given, Amor, amaris vel amare, amatur, et pluraliter, amamur, amamini, amantur.

In the early editions the use of contractions and the absence of capital letters made the text still more difficult to follow.

³ It was thus, they declined in Queen Elizabeth's time:—"Articles are borrowed of the pronoun, and be thus declined, *Singulariter, nominatiuo, hic, haec, hoc, . . . genitiuo, huius, . . . accusatiuo, hunc.*" *The Merry Wives of Windsor*. Act iv. Sc. 1.

⁴ *Commentarii Grammatici*, p. 13.

⁵ *Grammatica Sulpitiana cum textu Ascensiano*, Paris, 1503, 1506, 1513, 4to, London, by Richard Pynson, 1505, 4to, and many other editions.

The *De arte grammatica opusculum compendiosum* was printed at Rome in 1480, and by Richard Pynson at London in 1494.

⁶ *Grammaticae Institutiones*, Hagenau, 1512, 4to, edited with notes by J. Hildebrand. The earlier editions were Phorcae, 1508, 4to, and Leipzig, 1510, 4to.

⁷ *Grammatica noua fundamentalis* [Hagenau], 1513, 4to. He also wrote *Rudimenta Grammaticae et Encyclopædia orbisque doctrinarum*, 1519, and again 1520, 4to.

His complete works, edited by C. Von Halm, were published by the Royal Academy of Science of Munich, 1880-86.

See note on Aventinus in Prantl, *Geschichte der Logik*, iv. p. 295, Leipzig, 1870, 8vo; Gundling, *Historie der Galahrheit*, i. p. 259 n.

spaced and printed in tabular form. It gives some paradigms, and the words are supplied with German renderings.

In 1514, Johannes Murnellius of Roermond (1480-1517), the pupil of Alexander Hegius, published his *Nuclei*, an elementary grammar, containing all the forms of declensions of nouns and verbs. They are, however, printed across the page in unbroken lines and form solid letterpress, as in the example just given from the Oxford grammar.¹ Three years later he published Tables showing the inflexions of nouns and verbs.² This was an improved edition of the earlier work, in which the letterpress is opened up and to a certain extent put in tabular form. The declensions of nouns can be followed without much difficulty, but the schemes of the verbs are too closely packed together to be useful. Simon de Colines of Paris, the great printer, published, in 1529, an elaborate and curious work, *Grammatographia*,³ containing Tables of all the forms of the inflexions of nouns, verbs, and other inflected parts of speech, but they are too much condensed. The inflexions of verbs are clearly set out, but the use of symbols makes them troublesome to follow. The declensions are printed horizontally, but are opened out and well spaced, thus:—

	N	G	D	A	V	Ab.	
S. F.	Mus.	a	ae	ae	am	a	a science, doctrine.
		ae	arum	is	as	ae	is

¹ I speak from the edition Sanct. Ub. Agripp. (i.e. Cologne), 1525, 8vo. The forms of requests for leave of absence from school give a curious picture of the time.

² *Tabularum Opuscula tria pueris multo utilissima*. Daventriae, 1517, 4to; Colon, 1517, and again 1518, 4to, and many subsequent editions. See Reichling, *Johannes Murnellius, sein Leben und seine Werke*, p. 163, Freiburg-im-Br., 1880, 8vo.

The larger part of the *Tabulae* is taken up with the genders of nouns.

³ *Grammatographia ad prompte citoque discendam Grammaticen, Tabulas tum generales, tum speciales continens*. Paris, 1529, 4to. Again, 1533 and 1541, 4to.

There is a copy of the edition of 1533 in the British Museum to which it came with the Grenville Library. It was formerly in Heber's Library. There was a copy of the edition of 1529 in the Earl of Oxford's Library. *Bibliotheca Harleiana*, ii., No. 15,502.

Nicolas Bourbon of Vandœuvre, the poet, published *Tabellae necessariae*. Paris, 1539, 8vo, and Antonie Breguier, *Le clef de la langue Latine en tables*. Ib. 1663, fol.

There are two similar Tables in the Dresden Library—*Declinationes et Conjugationes Latinae linguae, xi. tabulis expressae*, Latin and German, 1568, folio. *Tabula de generibus Nominum latinorum*, 1568, folio. See Ebert, *Geschichte der . . . Bibliothek zu Dresden*, p. 129 No. 39, Leipzig, 1822. 8vo.

Andreas a Ruinellis published a series of elementary works on Latin Grammar for use in the schools of the Grisons (*in usum scholarum Rheticarum*), and amongst others, *Schemata in tabulas et questiones digesta*, Bas. Osten., 1590, 4to.

In a prefatory note de Colines explains that these tables were prepared for the use of Magdalene, eldest surviving daughter of Francis I. He refers to the advantage of teaching by the eye, as in the case of geography by means of maps. Tables of grammatical forms, he says, may be hung up on the walls of schoolrooms, but they are more convenient if put in book form. Besides the Tables of inflexions, the rules of syntax and other parts of grammar are exhibited in an abbreviated and tabulated form.

In 1549, Pierre Meganck or Megang, in Latin Petrus Megangus, who claimed to be of Ninive, and if so a fellow-townsmen of Despauter, published a tabular view of grammar,¹ but it is mostly in verse and just as difficult to follow as Alexander or Despauter.

Tanneguy Lefèvre, latinised Tannaquillus Faber (1615-72), the famous philologist of Saumur, when teaching his son, wrote out the schemes of nouns, pronouns, and verbs, with the prepositions and adverbs, on large sheets of paper which he had folded and bound to quarto size. Like de Colines, he recommended that they should be printed in this form and inserted in elementary grammars, as the imagination of pupils would be stimulated by the orderly arrangement, and their memories assisted. He also maintained that, if possible, paradigms should not be drawn into a second line.² This implies that paradigms of nouns and adjectives are to be printed across the page and not vertically as is now done.

The arrangement of such paradigms in vertical columns is, however, found in several early elementary grammars. A short grammar published by Wenceslaus Brack, of Constance, in 1486, contains examples arranged in vertical

¹ *Grammatica in Carmen, et Tabulas graphice concinnata*. Paris (Vascosanus) 1549, 4to; *Syn'axis certe quodam ordine tam in carmen quam in tabellas contracta*. *Ib.* 1549, 4to. This is a second part of the former.

As to the author, see Henne, *Histoire du règne de Charles-Quint en Belgique*, v., p. 44. Bruxelles, 1858, 8vo.

² *Méthode courte et facile pour apprendre les Humanités*, p. 8, London, 1703, 12mo. Originally published in 1672. The English translation by J. T. Philipps, tutor to the children of George II., London, 1721, 1723, 1750, is somewhat free and omits these details.

Lefèvre mentions that he could never read the Greek and Latin authors except in the editions of Plantin, d'Estienne and other skilful printers. He would learn 100 lines of Horace or Virgil in the beautiful Louvre edition more readily than 60 lines in any other edition.

Tanneguy Lefèvre was father of Madame Dacier.

columns as now,¹ with German translations attached. In the *Short Introduction to Grammar* by Dean Colet (1466-1519)² which is prefixed to all the later editions of Lily's *Grammar*, paradigms are given to a certain extent according to modern usage. This is more fully and better carried out in Cardinal Wolsey's *Rudimenta Grammatices* drawn up in English for the use of his school at Ipswich.³ This is a compact, simple and well printed grammar. The declensions of nouns, adjectives and pronouns and of verbs are set out as in modern grammars and are much better displayed than in the *Short Introduction*.⁴ Duarte Pinhel or Pinelli, a Portugese, published in 1543 a clear and well expressed manual⁵ with full paradigms and everything, as far as possible, put in tabular form or open printing so as to catch

¹ *Grammatica litteralis scientia*, Memming, 1486, 4to; 28 leaves without pagination.

² Colet's *Accidence*, otherwise known as Paul's *Accidence*, was first published in 1509 or 1510, but the earliest edition of which a copy is known is that of 1513. See *N. and Q.* 6th S. ii., pp. 441, 461.

³ *Rudimenta Grammatices et docendi methodus, non tam scholae Gysuichianae per reuerendissimum D. Thomam Cárдинаlem Ebôr. feliciter institutae, quam omnibus aliis totius Angliæ scholis prescripta* [London], 1529, 4to. There was an earlier edition but no copy of it is known to exist.

Cardinal Wolsey's *Letters to the Masters of his school at Ipswich* is given with an English translation in Tannaquil Faber's *Compendious way of teaching antient and modern languages*, translated by J. T. Philipps, p. 335, London, 1750, 8vo. 4th edition.

⁴ *A Short Introduction of Grammar generally to be used*. London, 1599, 8vo.

The typographical work is not so good as in Wolsey's *Rudimenta*. In the latter each verb is given separately. In this edition of the *Short Introduction* they are run together, e.g.,

Amo,	amas,	amat.
Doceo,	doces,	docet.
Lego,	legis,	legit.
Audio,	audis,	audit.

and so on, making it troublesome to pick out the right lines.

⁵ *Latinae Grammatices Compendia*, Vlissipone, 1543, 4to. He translated the Bible from Hebrew into Portugese. Ferrara, 1553, and Amsterdam, 1556, fol.

The excellent grammar of Emanuel Alvarez, a Portugese Jesuit (1526-83), *De Institutione Grammatica Libri. iii.*, first published at Lisbon in 1572, was in general use in Portugal until superseded by the *Nova methodus Grammaticæ latine* of Antonio Pereira, first published at Lisbon in 1752.

The Grammar of Alvarez was a useful, well-arranged manual, with paradigms in modern style. It was translated into English, London, 1686, 8vo; again [no place, but Douay (?)], 1707, 8vo; into German, 3rd ed. Ingolst., 1733, 8vo; again August. Vindel., 1794, 8vo; into French, Paris, 1708, 8vo; into Italian, Pavia, 1782, 12mo; and into Bohemian, Prague, 1695, 8vo; there were editions of the original Latin, Paris, 1859, 4to, Lyons, 1863, 12mo.

There were many editions of his Prosody, and it was several times translated into English. An edition for the use of the school of Drogheda was published at Dublin in 1819, 8vo; and a new translation, also at Dublin, as recently as 1859, 8vo.

the eye. A French work of 1549¹ follows the same method. The examples of nouns, adjectives and pronouns are arranged in vertical columns, as in present-day books, with the French rendering added; and are as prominent and distinct as in the most recent grammars. The inflexions of verbs are also arranged according to modern practice, with the translations attached. In fact, in so far as Accidence is concerned, the book is just what is now in use. Melanchthon² prints the declensions of nouns and verbs in the same manner as in modern grammars. Pierre la Ramée, known to us as Petrus Ramus³ set out the comparisons of adjectives in columns but printed the nouns horizontally across the page. He gives the inflexions of verbs according to modern practice, except that the tenses are not named. Martin Bachacziek of Prague published in 1591 paradigms of the declensions and in 1594 paradigms of the conjugations; the former set out, as we do now, with renderings in Bohemian and German, the latter in Bohemian only.⁴

The Rudiments drawn up for the use of schools in the province of Holland and West Friesland in 1628⁵ contains full paradigms

¹ *Les Declinaisons des Noms & Verbes, que doivent scauoir entiereement par cuer les enfans, ausquels on ueult bailler entree a la langue Latine.* Paris (De l'imprimerie de Robert Estienne) 1549 and again 1588, 8vo.

There is a copy of the earlier edition in the British Museum, (formerly in the Didot collection), and there was a copy of the latter in the Earl of Oxford's Library—*Bibliotheca Harleiana*, ii., No. 15526. There were still earlier editions. Paris (Nicolas le Riche) 1548, 8vo, *Catalogue de la Bibliothèque de Félix Solar*, No. 776, Paris 1860. Maittaire, *Annales Typographici* iii., pt. i., p. 385, cf. *Ib.* ii., pt. 478.

There is a chapter at the end (pp. 162-176) on the method of teaching children to decline nouns and verbs which is very much in accordance with modern practice.

² *Elementa Latinae Grammaticae*, Coloniae, 1527, 8vo; Magdeburg, 1548, 8vo. First published in 1525 by Chilian Goltstein without the author's sanction. It is reprinted by Bindseil, *Corpus Reformatorum* xx., p. 246, sqq., Brunsvigae, 1854, 4to. For bibliography see *Ib.*, p. 193-244.

³ *Grammaticae Libri quatuor*, Paris, 1560, 8vo, 3rd edition, dedicated to Charles, Cardinal of Lorraine. The dedication is dated in 1559; *Rudimenta Grammaticae Latinae*, *Ib.* 1565, 8vo. The privilege for printing is dated 11th June, 1557.

An attempt to unite the systems of Melanchthon and Ramus was made in *Grammatica Latina Philippo-Ramea*, Herborn, 1623, 8vo; Steinfurt, 1660, 8vo.

⁴ *Donati Declinationum Paradigmata*, Prague, 1591, 8vo; *Paradigmata Coniugationum Aelii Donati*, *Ib.*, 1594, 8vo. There was also published *Paradigmata Declinationum et Coniugationum*, Colon., 1541, 8vo.

⁵ *Linguae Latinae Rudimenta . . . in usum scholarum* [Hollandiae & West-Frisiae], Haarlem, 1628, 12mo.

It contains also a Vocabulary in Latin and Dutch, and concludes with the Ten Commandments, the Creed, the Lord's Prayer, prayer before undertaking any work, prayer before going to school, prayer before meat, grace after meat, prayer before going to bed, all in Latin and Dutch.

which are easy to follow. Those of nouns and adjectives are printed across the page ; those of verbs are shown as in grammars of the present time. This may, however, be looked on as a modern book. The same plan was followed by Thomas Farnaby (d. 1647), "the glory of our English criticks," in the grammar which he prepared under a commission by Charles I.¹

A large number of school grammars were, however, without paradigms. This is the case with the excellent grammar of Eloy Verger, headmaster of the school of Mâcon, *Grammatica pro pueris methodica ratione digesta*, Lugduni, 1547, 8vo, 3rd edition. The case endings of nouns are mentioned in describing the declensions, but a full example is not given by itself. The declensions of pronouns are given in full but in continuous horizontal lines ; and the declension of verbs are given in similar lines.

Despauter was a schoolmaster of experience² and a reformer, and if paradigms had been in use he would certainly have supplied them ; as he did not, he evidently considered that they were not required in a grammatical work. Everything thus depended upon the teacher. The grammar book was for him, not for the pupil. Practical tuition must in this way have been carried on principally by oral teaching, and by the use of wall-sheets and tables.

There are many complaints, in the numerous writers upon educational methods in the sixteenth and seventeenth centuries, regarding the home or private work exacted from boys ; but this must have been upon what was dictated at school as there was nothing in Despauter's *Rudimenta* and similar works which a boy could learn from the book. The same observation applied to such a book as Novimola's abridgment. Its only use was to provide the text of the metrical rules. These were gone over and explained in school, and the pupil no doubt spent much time at home in painfully committing them to memory.³ He was sup-

¹ *Systema Grammaticum*, Londini, 1631, 8vo. See Twell's *Grammatica Reformata*, p. 18. London, 1683, 8vo.

² Despauter studied at Louvain under Jean Custode of Brecht, a famous grammarian of the time. He subsequently taught at Louvain, Bois-le-Duc, Berg-Saint-Vinox, and at Comines, where he died in 1520. Foppens, *Bibliotheca Belgica*, ii. p. 628, Bruxelles, 1739, 4to.

³ There are frequent references in the colloquies of Mathurin Cordier (1479-1564) to home work. In one (Lib. i. 7, p. 9, Paris, 1568, 8vo), five passages (*lectiones*) are marked in the *Rudimenta* to be committed to memory. Gaspar Scioppius at the end of a dissertation "De veteris ac novae Grammaticae latinae origine," prefixed to this *Grammatica Philosophica*, Mediol., 1628, 8vo,

posed to have learned the Accidence before taking up the metrical rules but it was necessarily again gone over more fully, and must have been taught by verbal explanation and dictation. Although Murmellius did something to enable children to learn the Rudiments by the eye, he maintained that printed sheets should be supplemented by dictation, as by writing out what was spoken—children learnt to spell and fixed the matter in their memories.¹ Erasmus, writing in 1529, refers to his schooldays experience, about 1475—"Good Lorde, what a world was that, whan wyth greate boastyng John Garlandes verses wer read to yonge men, and that with longe and painefull commentaries: whan a great parte of tyme was consumed in Folyshes verses, in saying them to other, repetyng them, and hearyng them agayne: whan Florista and Floretus were learned without book."²

Nowadays we have whole libraries of grammars purporting to enable one to learn this or that language "without the aid of a master." The same idea occurred to Hermann Schottenn of Hesse, a schoolmaster at Cologne in the early part of the sixteenth

gives a synopsis of the duties of master and pupils respectively, which lays a considerable burden upon the latter in the way of committing to memory parts of the grammar. Amongst others they are to learn the verses of Sanctius, "De genere Nominum," and "De Declinationibus." Emanuel Alvarez recommends that, in teaching the declensions, the master should give out in school a noun coupled with an adjective, and that the scholars should write them out at home through all the cases and bring them next day for correction. This, he considerably adds, was "ne otio diffuant." *De Institutione Grammatica*, p. 14, Genuae, 1674. 12mo. See also Jonas Philologus *Dialogi*, iii., p. 7. Paris, 1555, 8vo.

¹ *Enchiridion Scholasticum*, c,xvi. p. 47; c,xx. p. 54, ed. Bömer, Münster, 1892, 8vo.

He recommends that boys should comb their hair frequently, as this strengthens the memory. *Ib* p. 34.

Beaver's fur worn on the head strengthens the memory, and it has been suggested that this may have given rise to the fashion of wearing beaver hats. *The Philosophical Transactions Abridged*, vii. p. 264.

² *A Declamation that chyldeuen euen strayt from their Infancie should be well and gently broughte vp in learnynge. Written fyrst in Latin by the most excellent and famous cleark, Erasmus of Roterodame*, sig. Pii verso; appended to Rychard Sherry's *Treatise of Schemes and Tropes*, London (John Day), 1550, 12mo. This is a translation of Erasmus' *Declamatio de Pueris ad virtutem ac literas liberaliter instituendis*, Opera, i. p. 514; Lugd. Bat., 1703 fol.

In the above passage he adds:—"For as for Alexander, I thynke him worthye to be received amonge the meaner sorte (*inter tolerabiles numerandum*)."

The *Florista* was a metrical syntax by Ludolph von Luchow, Canon of Hildesheim, and composed in 1317. Johann Müller, in *Anzeiger für die Kunde der deutschen Vorzeit* 1878, No. 11. Haase, *De mediæ ævi studiis philologicis*, p. 42, Breslau, 1856.

The *Floretus* is attributed by Dom Rivet de la Grange (*Histoire littéraire de la France*, viii. p. 91) to John de Garlandia and is dealt with as part of the Facetus. *Infra.*, p. 28.

century, who published an elementary Manual to enable boys to imbibe letters and sound principles with ease and without the Herculean labour of teachers (*sine praeceptorum Herculeo sudore*); but however excellent may have been his intentions, the labour of learning by means of his book, even with the assistance of a master, must have been very great. After defining grammar, giving explanations of syllables, words, and the gender of nouns, of figure, number and case, he comes in the thirteenth Dialogue to the declensions of nouns. He refers to the standing example *Musa* in *Donatus minor*, and then mentions the genitive, singular, and plural of *Tunica*, but the full declension was to be sought for elsewhere as it is not given here.¹

Johann Buno, of Lüneburg, spent a great deal of time and ingenuity in devising a system of graphic illustration to enable the reader to grasp and his memory to retain information of all kinds. Amongst other works he produced an improved Latin grammar plentifully supplied with cryptic devices intended to assist the pupil in mastering the parts of speech and even the rules of syntax, but it is not provided with paradigms. Examples are given of the declension of German nouns, but curiously not of Latin ones.²

Part III. of Despauter's *Rudimenta* is founded, to some extent, on the *Regula Remigii*, that is of Remi of Auxerre (d. 908).

The next treatise in the *Commentarii Grammatici* entitled

¹ *Instructio prima Puerorum, a legendi peritia, tum in Grammaticae, tum Morum praeceptis ut sine praeceptorum Herculeo sudore, facili opera pueri & literas & mores honestos imbibant per Colloquia mutua.* Apud Foelicem Vbiorum Coloniam (i.e. Cologne), 1527, 8vo. It is dedicated to Matthias Sterkenberch, one of his pupils.

Part ii. is *De Moribus*, and gives directions for proper behaviour in all circumstances and all times, and gives an interesting insight into the customs of the day.

The book was reprinted by Wynken de Worde, London, 1533, 8vo. There was a copy in Heber's Library. *Catalogue*, Part ii., No. 5325.

² *Neue lateinische Grammatica in Fabeln und Bildern den eüsserlichen Sinnen vorgestellt.* Dantzig, 1651, to. He applied his method to law and history; *Memoriale Institutionum Juris*, Ratzeburgi, 1672, 4to, which includes the Institutes and the title of the Digest, "De Verborum significatione"; *Memoriale Juris civilis Romani*, Hamburgi, 1673, fol.; *Memoriale Codicis Justiniani*, Ib., 1674, fol. *Historische Bilder*, Lüneburg, 1672, 4to; Mittenberg, 1692; Ratzeburg, 1705, both 8vo. This is a sketch of Universal History. The Bible was also similarly treated. The plates in the various works are very curious, but not of much practical utility.

Buno was a Lutheran clergyman, born at Franckenberg, in Hesse, in 1617, and died in 1697 at Lüneburg, where he was rector of the school.

"The First Part of Grammar," is that which forms the substance of Novimola's abridgment and the Scotch school book. In an address to Balduin Braets, Doctor of the Canon Law, dated 16th August, 1512, the author explains the purpose of the book. The *Doctrinale* of Alexander¹ was, he says, in the opinion of scholars unsuitable for boys as being obscure, prolix, barbarous, defective, and erroneous.² Many attempts had been made to improve it without much success; and some of the writers, as for instance, Hermann Torrentin (Van Beeck), rector of the school of Zwolle,³ confined their labours to mending his verses. The result was a multiplicity of grammars, so that in scarcely any schools were the same books used. This was a loss to the pupils, as when they were transferred to another school they were apt to find that all that they had already learned was so much time lost.⁴ The only remedy was that one author should be selected for general use. "*Hic quis erit, novit Deus.*" In these circumstances Despauter, no doubt in the expectation that he should be that one, applied himself to the preparation of a better grammar, and drew up the first part Syntax and Stichology or the Art of Verse. This, he remarks, was generally thought to be an easy matter, and every usher considered himself fit for it;

¹ *Supra*, Part i., p. 24.

² Alexander Barclay, about the same time, writes :—

But of gramar knowe they lytyll or no thyng
Whiche is the grounde of all lyberall cunnyng,
Yet many ar besy in Logyke and in lawe
When all theyr gramer is skarsly worth a strawe,
If he have onys red the old doctrinall
With his diffuse and unparfyte breuyte,
He thynketh to have sene the poyntis of grammer all.
And yet of one errour he maketh two or thre
Precyan or sulpice disdayneth he to se,
Thus many whiche saye that they theyr grammer can
Ar als great folys as whan they firste began.

The Ship of Fools, translated by Alexander Barclay, i. p. 144, Edinburgh, 1874, 4to. This is one of Barclay's additions. It is not in Brant's original. *Das Narrenschiff*, ed. Strobel p. 130. Quedlingburg, 1829, 8vo. In the original the universities to which the student repairs are Leipzig, Erfurt, Vienna, Heidelberg, Mentz, and Basel. In Barclay's version he wanders to Paris, Padua, Lombardy or Spain, Bologna, Rome or Orleans, Caen, Toulouse, Athens or Cologne.

³ *Supra*, Part i., p. 25.

⁴ Change of school was evidently a fashion of the day. Murmellius speaks of a boy having been at as many as a dozen of schools.

but it was not the case. Boys were taught in a roundabout and unsatisfactory manner, as for instance,

Per es breue, es longum, etc.¹

'For if you interrogate Alexander, "What is the genitive of *trames*?" he will reply "*Tramitis*, because it is a masculine in short *es*." "But why is it masculine?" "Because it ends in short *es*." "I do not know, my Alexander, which nouns end in *es* short and which in *es* long, I pray, therefor, tell me why *trames* ends in *es* short?" "Because a noun ending in *es* whose genitive *itis* makes the penultimate short, shortens *es*." Hear how neatly the noble grammarian eludes the boys.'² Despauter himself does nothing to clear up the difficulty. *Nihil esse in re grammatica incertius genere*, says Francisco Vergara³ of Toledo, the celebrated Greek scholar (d. 1545), and modern linguistic does not help us.⁴ But while Despauter criticised the *Doctrinale* he had every respect for the author. Whatever were the faults of Alexander, these, he remarks, belonged to the age

¹ This is from the *Doctrinale*, 150, 151.

Mas aut commune, si fiat in es breuiatam,
E mutans dat itis; miles fiat tibi testis.

Substantives in *es*, gen. *itis* are masculine, except *mergēs* which is feminine. Ruddiman's rule was not very explicit:—

Hæc dabit *es*. Capient *ales* Hic Hæcve, *palumbes*,
Atque *dies*: sed *mas proles*: *mas poples et ames*,
Fomes, pes, paries, palmes cum *limite stipes*,
Queis addes *trames, termes*, cum *gurgite, cespes*;
Et quæ fonte fluunt Graio: sed neutra capessunt
Hippomanes, panaces, nepenthes, sic *cacoëthes*.

This is a fair sample of the metrical rules and shows how difficult it is to give any satisfactory guide dependent on form for determining gender. Alexander, on the whole, was quite as successful as any of his successors.

In a recent publication, *Latin Genders, A practical method of learning them*, by B.A. Cantab., London, 1903, 8vo, the rule is put thus (p. 8):—"Masculine are nouns in *es* (increasing);" but this mixes up *es* long and *es* short.

² *Commentarii Grammatici*, p. 24.

Despauter makes a similar observation in his commentary on Hermann Torrentin, *Hermanni Torrentini . . . in primam partem Alexandri Galli . . . commentarius, Iohan. Despauterii . . . annotationibus . . . locupletatus*. Sanct. Ubiorum Colonia, 1522, 4to, f. 14. This work is dedicated to Wilhem Zagar, schoolmaster at Zierikzee.

³ *De omnibus Græcæ linguæ Grammaticæ partibus*, Paris, 1550, 8vo, quoted by Sanctius, *Minerva*, i., c. 7, p. 43, Amst., 1714, 8vo.

⁴ In modern grammar *trames* is distinguished as a consonant stem with a derivative affix *ēs*, genitive *itis*. The members of the group are masculine, except *merges*, which is feminine.

and not to the man ; his object was to make the path easy for boys, not to obstruct it.¹

Despauter devotes much attention to heteroclites and to preterites and supines ; which, in the opinion of some,² were merely a rack for the minds of children. While his verses, he says, are fewer than those of Alexander no essential rule has been omitted. He gives long lists of old and foreign words, not that the pupils should learn them all, but as a fund to draw upon. The skilful teacher will select for each pupil what is best, although some teachers are not judicious and do not recognise the different capacities of their pupils.

Prima Pars consists of seven books. The first is *De Nominum generibus*, and commences :—

Omne viro soli, quod convenit, esto virile.

Omne viri specie pictum, vir dicitur esse.

This is retained by Novimola. The gender of angels is often in controversy nowadays, but the grammarians had no doubt. The names of angels, says Despauter, whether of the good, as for instance, Gabriel, Uriel, Michael, or of the bad, as Lucifer, Beelzebub, are masculine, as are also Cherub and Seraph, although the plurals Cherubim and Seraphim are doubtful.³

The treatment of gender as the first subject is an alteration of the traditional arrangement, which began with the declension of nouns. This, in Despauter, follows in the second book *De regulari*

¹ *Commentarii Grammatici*, p. 180, cf. p. 182.

George Buchanan, speaking of the wretched condition of the teachers of the humanities in Paris, says—

Et queritur nullis onerari compita chartis,
Esse & Alexandrum nullo in honore secum.

Elegiarum Liber, i., 69.

² *Examen de la maniere d' Enseigner le Latin aux enfans par le seul usage*. Paris, 1668, 12mo.; *an Examen of the Way of Teaching the Latin tongue to little Children by use alone, Englished out of French*. London, 1669, 8vo. There is a copy in the British Museum, (C. 33, a. 24). The author advocates (pp. 21, 27) the stating of the rules in French instead of in Latin, and the giving of as few rules as possible. His plan was to teach children Latin from infancy instead of their mother tongue. A difficulty was where the parents did not know Latin ; but this was not to be allowed to stand in the way.

³ Alexander gives the same rule, *Doctrinale*, 514 :—

Angelicum nomen dabit hic ; sed dicito neutra
Plurali numero Cherubin Seraphinque beata.

Nominum declinatione. The rule for the first declension is given thus :—

Prima dat as, es, e, rectis, & a. Patrius ae vult

Cum terno. Sed ab e recto, genitiuus in es fit.

Casibus his Adam tantum flectunt & Abraham.¹

This is likewise retained by Novimola and was the rule taught to almost all schoolboys in Scotland for well nigh two hundred years. Despauter's commentary assumes that the pupil has already learnt the declensions from the Rudiments.

The third book treats of heteroclite or irregular nouns; the fourth of comparison, the fifth of preterites and supines, the sixth of defective and anomalous verbs, and the seventh of the forms of verbs.

The Syntax, like the other parts, is introduced by a dedication, and by a preliminary chapter on the excellence of grammar. It concludes with four commendatory poems by friends and two prose letters by the author.

The old writers were fond of distinguishing between *grammaticus* and *grammatista*. A *grammaticus*, i.e. a grammarian, is, according to Despauter, following Suetonius, one who can speak and write with ease, insight, and knowledge, and can expound the poets, otherwise he is styled *litteratus*, a man of letters, a scholar. A *grammatista*, i.e. a grammarmaster² is one who makes a din over barbarous letters, with whom abuse takes the place of use, who gives a Latin etymology to Greek words and is wholly concerned with trifles. In Latin he is termed *literator* or *litteroedus*, a smatterer.³

The rules of Syntax, like all the other rules, are given in verse, each supplemented by a commentary in the form of question and answer, which Despauter, following the example of Perotti and Aldo Manuzio, considered the most suitable form.⁴ The rules

¹ It is a question whether Alexander's rule, *Doctrinale* 29, is not the more explicit. It begins :—

Rectis as, es, a dat declinatio prima.

² Martianus Capella, 3, § 229 gives *grammatodidascalus* as the equivalent of *grammatista*. See Suetonius, *De illustribus Grammaticis* 4 and 24; A. Wittich, *De Grammatistarum et Grammaticorum apud Romanos scholis*. Eisenach, 1844.

³ How angry grammarians can become may be seen from the following :—*Invectiva in Grammatistas & ignaros litterarum paedagogos ac praecipue in Alpheum quendam omnium foedissimum, in Patricios item illorum fautores, & in discipulorum nostri temporis ignaviam et mollitiem.* Fani, 1502, 4to. There was a copy in the Pinelli Library, Catalogue No. 12,163, London, 1789, 8vo.

⁴ *Commentarii Grammatici*, p. 182.

are too numerous, sometimes they are too special and occasionally not logical. The commentary is packed full of matter; it is plainly written, but is too diffuse and is bald and unattractive in style.

The opening rules are :—

Mobile cum fixo, genere & casu, numeroque
Conueniat Nomen sic vult cognomini adesse.

Pone relatiuum cum præcedente in eodem
Et genere & numero; nec non persona in eadem.

These are old friends, familiar to all who have learnt Ruddiman's *Rudiments*, either in its original form or as adapted in the *Edinburgh Academy Rudiments*, if we bear in mind that *mobile* and *fixum* mean respectively adjective and substantive.¹ The addition to the first rule that *nomen* and *cognomen* agree in gender, number, and case, seems unnecessary; and the phrase "vult cognomini adesse" is hardly self explanatory.

Throughout the Middle Ages grammar was dominated by metaphysics and logic. Aristotle was appealed to as an authority upon every point, and the *Metaphysics*, the *Physics*, and the *De Anima* were all cited or referred to for the determination of questions of grammar. The why and the wherefore of everything was investigated. Hence arose the distinction between the signification of a word and the manner of signifying (*modus significandi*), or the reason why it had its signification.

Each word has its own property or essence (*modus essendi*). The intellect in grasping this essence or property imparts to it signification (*modus significandi*), and words become parts of speech. *Modi significandi* were essential or accidental, general or special; essential when they related to the essence of a part, accidental when they were superadded.² The *modi significandi*

¹ This is derived from Donatus *Ars Grammatica*, ii., p. 3.

² See Thurot, *Notice et Extraits des Manuscrits* xxii. Part 2 (1868), pp. 124, 125, 128, 130, 151, sqq. 156, 200; Prantl, *Geschichte der Logik*, iv, p. 104, Leipzig, 1870, 8vo. Kaufmann, *Die Geschichte der deutschen Universitäten*, i. p. 23; Haase, *De mediæ ævi studiis philologicis*, p. 39, Breslau, 1856; Johann Müller, "Ueber die Modisten" in *Anzeiger für die Kunde der deutschen Vorzeit* N.S. xxv. (1878) pp. 233, 351; Baebler, *Beiträge zu einer Geschichte der lateinischen Grammatik im Mittelalter*, p. 74. Halle, 1885, 8vo. *Das Doctrinale des Alexander de Villa-Dei*, ed. Reichling, p. c. vi., Berlin, 1893, 8vo.

While the *Modista* lost themselves in metaphysical speculation they did much to place grammar upon a philosophical basis, and a good deal of this work was quietly appropriated by succeeding generations. See Haase, *supra*.

were regarded as the flowers of grammar ; and one of the treatises read to Gargantua, by his first teacher, the great sophister doctor, called Master Thubal Holophernes, was the book *De modis significandi*,¹ with the commentaries of Hurtebise, of Fasquin, of Tropditeux, of Gaulehault, of Jehan de Veau, of Billonio, of Brelinguandus, and a rabble of others.² "Unhappye was the tyme whan I was a child," writes Erasmus, "whiche al to vexe the youth with modes of signifyinge, and other folyshe questions, & teching nothings els then to speake folishelye. Wereby those masters bicause they wold not be thought to teach folish thinges, darckened grammar wyth difficulties of Logicke and Metaphisike."³

The humanists, laying aside this old, arid doctrine, held that it was of no importance to know in virtue of what power (*ex qua vi*) one word governed another, and such inquiries, they contended, were merely hindrances to the progress of pupils.⁴ "Take the example *liber Petri*," says Despauter. "In virtue of what (*ex qua vi*) is *Petri* governed? By force of will and the usage of men of education. Give the rule :

Quærenti vires sit pro ratione voluntas,
Assiduusque vsus magnorum grammaticorum.

¹ By Duns Scotus, and included in his works by Wadding, *Opera omnia*, i. p. 45-76, Lugd. 1639, fol. It was printed along with a *Lectura* by Maurice O'Fihely, Archbishop of Tuam, Venice, 1519, folio, and is included in his collection, *Hoc ex frontispicio*, Pavia, 1520, 8vo ; and has recently been edited by Mariani Fernández García, O.F.M., *Joannis Duns Scoti Grammaticæ Speculativæ nova editio*, Quaracchi, near Florence, 1902, 12mo, who is of opinion that it was written at Oxford in 1293. See Prantl, *Geschichte der Logik*, iii. p. 215, iv. p. 269. The authorship has also been attributed to Albert of Saxony, and it was so attributed in an edition printed at St. Albans in 1480, and again by Wynkyn de Worde in 1515, and in another edition without date ; also in an edition published at Antwerp (Godofredus Back), without date. There is a copy of the 1480 edition in the Bibliothèque Nationale. See Pellechet, *Catalogue général des Incunables des bibliothèques publiques de France*, i. p. 56, No. 260. Albert was an Augustinian, and Ossinger claims him as the author of the book. *Bibliotheca Augustiniana*, p. 799, Ingolst., 1768, fol.

² Rabelais, *Gargantua and Pantagruel*, i. c. 14. By "sophist" Rabelais meant Sorbonnist. Arnstädt, *François Rabelais und sein Traktat d'Education*, p. 121. Leipzig, 1872, 8vo.

³ Erasmus, *Declamacion*, p. ii. *recto*. *Supra* p. 19. The original is "Sed infelicioer erat aetas quæ, me puero, modis significandi et quaestiuiculis ex qua vi, pueros excarnificabat nec aliud interim docens quam perperam loqui." *Opera* i. p. 514.

⁴ They were attacked by Alexander Hegius in his "Invectiva in modos significandi," *Dialogi*, Davenport, 1503, 4to.

The *Liber modorum significandi* was, as above mentioned, printed at St. Albans in 1480, and was twice reprinted by Wynkyn de Worde once in 1515, and once without date, so that the *Grammatica speculativa* still held its ground in England, until the Reformation.

If anyone shall ask in virtue of what is a word governed you will reply in virtue of the will and uniform usage of the most learned grammarians, orators and writers. Alexander and many others have sadly plagued both themselves and wretched boys regarding the force of the government of words. They did not think it enough to say that *liber Petri* is correct, because scholars always say so. They might ask why don't we say *Petrus vaccae*, *Iohannes chimærae* just as we say *vacca Petri*? There ought to be a certain relation (*habitus*) of the word governing to the word governed: But that relation, say they is the power of government (*vis regiminis*). But, however this may be, it is harmful to boys because it is unnecessary and of no use for knowing Latin, and must, therefore, be laid aside. It is enough for boys to answer *liber Petri* is good Latin because scholars so speak, following the rule that where there are two substantives, one denoting the possessor and the other that which is possessed, the former is put in the genitive case. But why don't we say *Petrus libri*? Because it is not good sense, the book does not possess Peter, but Peter possesses the book. This is enough for boys. So too, why has *pedo* not *pesi* as *laedo* has *laesi*, or why has *do* not *davi* as *flo* has *flavi*? There is no reason or power save the will of authors or the constant practice of educated persons."¹ Despauter then sets out, for the benefit of the curious, three-and-twenty relations of substantives falling under this rule. The word expressing the thing possessed governs the word expressing the possessor as *liber Petri*, that is the book which Peter has or possesses. The part governs the whole as *ungula equi*, *crista galli*, *pupilla oculi*; and so on. But long as is the list Richard Johnson, headmaster of Nottingham Free School, states that it is neither complete nor correct, and that it is of no use for boys.²

The *Ars Versificatoria* is a long treatise, in three books "*immensi laboris pelagus*" as the author fitly terms it.³ The third book is dedicated to the author's friend and countryman, Josse Bade of Aasche in Brabant, otherwise known as Jodocus Badius Ascensius,⁴ the learned Parisian printer. It is followed

¹ *Commentarii Grammatici*, p. 227.

² *Noctes Nottinghamicae*, p. 8, Nottingham, 1718 8vo, referred to by Ruddiman, *Grammaticae Latinae Institutiones*, Part ii., p. 40.

³ *Commentarii Grammatici*, p. 413.

⁴ Of Badius Ascensius, see Emmanuel Hoyois in *Mémoires et Publications de la Société des Sciences . . . du Hainaut*, 1841-42, p. 195, Mons, 1842, 8vo.

by a short chapter on accents or prosody, which was reprinted at London by Wynkyn de Worde in 1525. This is followed by another on the different kinds of verse. The treatise *De figuris* relates to the figures of speech, more generally included under Rhetoric.

The *Ars Epistolica* is a manual on the art of letter writing founded largely on those of Erasmus,¹ Bebelius,² and others. It is interesting in itself and contains a great deal of curious information. The subject was an accepted part of a treatise on grammar. Perotti and Sulpicius deal with it at length.³

The last part of the *Commentarii Grammatici* is *Orthographia*.

In a dedication of the *Ars Versificatoria* to Joannes Laurentius of Hazebrouck, Despauter mentions that a great outcry had been made by a crowd of ignorant persons against his previous works on grammar, as being an attempt to dethrone Alexander Gallus. They declaimed against him as the inventor of a fatuous novelty and as one bent on teaching in opposition to the usage of the church. Deans and canons, officials and bishops read the offices of the church according to the rules prescribed by Alexander "and do you think that you are wiser than they?" "His accusers," he replies, "were an ignorant pack who no more understood an ancient author, than a boy in his Rudiments understood Virgil. They did not know Homer from Justinian." What they wanted was the *glossa notabilis* upon Alexander,⁴ the Graecismus of the Fleming, Eberhard de Bethune⁵ or the *Facetus*,⁶ ascribed to the Englishman John de Garlandia. "Like

¹ *Libellus de conscribendis Epistolis*, Cantab., 1521, 4to. There were very many other editions.

² Henrici Bebelii, *Commentaria Epistolarum conficiendarum*, Phorce, 1509, 4to.; Argentinae, 1513, 4to, and many other editions.

³ *Grammatica Nicolai Perotti cum textu Iodici Badii Ascensii*, fol. lxix. verso to xcvi. verso, Paris (Jehan Petit), 1504, 4to; See *Grammatica nova* by Bernhard Perger, edited from Perotti, [Cologne], 1485, 4to; [Venice], 1488, 4to.; and Sulpicius *De componendis et ornandis epistolis*, in the *Grammatica Sulpitiana*, Paris, 1513, 4to. There are many other editions.

"Complete letter writers" were to be found in the Middle Ages as now. See Böcking, *Epistolae obscurorum virorum*, ii. p. 417, Lips., 1870.

⁴ Of the *Glossa notabilis* upon the *Doctrinale* see Thurot *Notices et Extraits des Manuscrits* xxii., Part ii. (1868), p. 488; Reichling, *Das doctrinale des Alexander de Villa Dei*, p. lxiv., Berlin, 1893, 8vo.

⁵ See Thurot, *supra* p. 100; Reichling, *supra* p. lxxix.

The most convenient edition of the *Graecismus* is that of Professor Johann Wrobel of Czernowitz, Wratislav., 1887, 8vo.

⁶ The *Facetus* was a moral poem intended as a supplement to the Distichs of Cato and has been ascribed by Dom Rivet de la Grange to John de Garlandia (*Histoire littéraire de la France*, viii., p. 87; Paris, 1747, 4to).

lips, like lettuce, like has met its marrow, asses prefer straw to gold. I do not care a pin for their attacks if I please scholars."¹

In turning over the closely printed pages of the Paris edition of the *Commentarii Grammatici*, or the even less attractive pages of the small quartos in which the separate treatises originally appeared, it is difficult to realise that these disquisitions, which now seem tame and dull, once excited so much feeling. Despauter, however, was an eminent grammarian² and his works mark a stage in the history of grammar and of the methods of education. Opposition to the use of the *Doctrinale* and attempts at improvements had been going on for a considerable time and Despauter's were, in some respects, the most successful. He could not, however, break with custom so far as to reject metrical rules, which, in consequence of the hold which his treatise had in Scotland, have remained in a modified form down to our own time. His grammar³ was universally adopted in Flanders and to

The authorship has also been ascribed to Reinerus Alemanni (d. 1212), but Don Rivet rejects this, *ib.*, p. 88.

It was a favourite school book, and passed through numerous editions. Before the end of the fifteenth century four had appeared at Davenport in 1492, 1494, 1496 and 1499; two at Cologne, and one at Rouen all without date, and one at least at Paris; *Facetus cum Commento*, Paris (Mich. le Noir), 1498, 4to. A copy of the last was in Chancellor Croft's library. *Bibliotheca Croftsiana*, No. 192, London, 1783, 8vo.

It was translated into German by Sebastian Brant. Of the translation four editions at least appeared in the fifteenth century, and several of later date.

It is also contained in the well-known manual, *Auctores Octo*, Lyons, 1488, 1489, 1490, 1492, 1493, 1494, 1495, 1496, 1498, 1499, 1500, 1519, 1525, 1538; Cologne, 1490; Angoulême, 1491; Caen, 1508, 1517. See Pellechet, *Catalogue général des Incunables des Bibliothèques publiques de France*, i., p. 329.

It will be remembered that Gargantua learned his A, B, C, from the great sophister doctor called Master Thubal Holophernes. Then the doctor read to him the Donat, the Facet, Theodolet and Alanus in *Parabolas*; and his next master Jobelin Bude treated him, amongst others, to the *Doctrinale*, and the *Gracismus*. Rabelais, *Gargantua and Pantagruel*, i., c. 14.

Theodolet, and Alanus are also contained in the *Auctores Octo*, so that we may infer that Rabelais had used that manual at school.

As to John de Garlandia, see further Hauréau in *Notices et Extraits*, *supra*, xxvii. (1869) ii. Part, p. i.

¹ *Commentarii Grammatici*, p. 361.

² Vossius terms him "Grammaticorum suae aetatis princeps." *Aristarchus* p. 458, "De Analogia" i. c. 19. Amst. 1662, 4to.

³ There was an abridged edition by Behourt, Trecis, 1658, 8vo, and later editions.

As to Despauter see Baillet *Jugemens des Savans*, ii., part iii., p. 71, 76, Amsterdam, 1725, 12mo; Professor Baebler "Das verbesserte Doctrinale Perottus und Despauterius" in his *Beiträge zu einer Geschichte der lateinischen Grammatik im Mittelalter*, p. 135, Halle, 1885, 8vo. Eckstein, *Lateinischer Unterricht*, p. 49, Gotha, 1880, 8vo, a reprint from Schmid's *Encyclopädie*, and again Leipzig, 1887, 8vo.

a large extent in France and, in Novimola's abridgment, was more generally used in Scotland than any other.¹

Despauter's *Orthographiae Isagoge* was published in 1510; his *Rudimenta* and *Prima Grammaticae pars*, in 1512, and his *Syntaxis* in 1515. A German contemporary, Johann Pincianus, also a reformer of grammatical teaching, published an improved grammar at Augsburg, in 1515, which he dedicated to Conrad Peutinger, whose two sons seem to have been under his charge.² He mentions that boys had long been taught by means of Gallus de Villa Dei, and that in Germany no other grammar had been allowed,³ but the time for better things had arrived, and he accordingly put forth this work as an attempt to supply what was required. It is an excellent manual, and although it did not meet with the success which fell to Despauter's grammar and its abridgments, it was their superior for practical use by pupils. The declensions of nouns are shown in vertical columns, and the paradigms of verbs are given in accordance with present practice. A large number of the Latin words have German renderings.

Schoolboys, we know, were expected to use books,⁴ but from the failure of grammars with paradigms to get into circulation teachers apparently did not encourage their learning the inflexions from this source.

¹ Haase's geography is somewhat out of joint, as he takes Scotland to be part of England. Despauter, he says, was in general use in England until the advent of Ruddiman in the beginning of the eighteenth century. *Vorlesungen* p. 20, Leipzig, 1874, 8vo, *Infra*, p. 50.

² *Epitoma Grammaticae, Vna cum Praeceptis moralibus ad iuventutem*. Augustae, 1513, 4to. Pincianus was also the author of an interesting vocabulary, Latin and German, *Promptuarium Vocabulorum*, 1516, 4to, likewise dedicated to Conrad Peutinger. It was founded on the work of Marius Grabaldus. Pincianus was a priest at Augsburg.

³ In the old days at Leipsic, says Master Conrad Unckebugck, when a student of grammar walked abroad he carried under his arm the "Partes" of Alexander, the "Vademecum" (see *supra*, p. 11), the "Exercitium puerorum," the "Opus minus," or the "Dicta" of Johannes Sinthen. *Epistolae obscurorum virorum* ii. 46, pt. i, p. 258., ed. Böcking, Lips., 1864, 8vo. The *Epistolae* are naturally full of allusions to Alexander and his passing reputation.

⁴ There is a woodcut of a teacher, with two pupils beside him, on the title-page of the *Grammatica nova* (Cologne, 1485?), *supra*, p. 28. Each of the boys holds a book, but it may be a reading book, not a grammar. Wynkyn de Worde uses two similar woodcuts. One of a schoolmaster in his chair with a birch in his right hand, three scholars at his feet with books in their hands. The other is similar, but the master has the birch in his left hand, and the boys have no books. In an ornamental capital at the beginning of *Doctrinale totius grammaticae artis*, Nuremberg (Hier. Holtzel) n.d., a schoolmaster sits at a desk with two pupils before him. They have books and he has a formidable birch. As to books for schoolboys see Murmellius, *Enchiridion*, p. 52.

Despauter's verses had their use. When Marthe Brossier, the contortionist, was parading France, as one possessed of a devil and requiring to be exorcised, she came to Orleans about 1598. There the bishop presented her with a Despauter bound in the old style. Marthe took it for the devil's flail, and trembled when she merely looked upon the two pigskin-covered boards and brassen clasps. The book was opened and she was asked to read. The passage she lighted upon was—

Nexo, xui, xum ; vult, Texo, xuit, indeque textum.

This she took to be a most potent exorcism and forthwith turned head over heels and bounded along the ground. She was next tested by perfume, and the two tests having shown that she was an imposter, the Official of Orleans enjoined the clergy of the diocese not to exorcise her under pain of suspension.¹

The editions of Novimola's abridgment and its various parts were very numerous. One of these issued by Peter Horst at Cologne in 1574, 8vo, is interesting from having appended to it an index of the words occurring in the Grammar, with their renderings into German, by Bernard Fabricius, Aquensis, for the school at Montani (? Berg). In the Edinburgh edition of 1621² the meanings of the principal words are given in Scots. The renderings were retained in all subsequent editions, and were slightly changed from time to time, no doubt to suit the language of the day. It may therefore be of interest to present a few of them as given in the edition of 1621, and that of Glasgow, 1672, and to add the German versions of Fabricius.

¹ Bayle, *Dictionnaire*, s. v., Brossier, who quotes Matthieu, *Hist. de la Paix*, Liv. ii. narrat. 3, p. 337. I cannot trace the reference. Matthieu, *Histoire de Henri IV. de France*, Liv. ii. in vol. ii. p. 301 (Paris, 1631, fol.), when mentioning the occurrence, says nothing regarding the grammar. According to De Thou (*Histoire*, vol. v., Book 123, anno 1599), it was the first line of the Æneid which was used as the test. Congnard, *Histoire de Marthe Brossier* . . . tirée du Latin de Messire Jacques August de Thou, p. 2, Rouen, 1652, 4to. The case caused a great sensation at the time. See *Discours véritable sur le fait de Marthe Brossier de Romorantin prétendue démoniaque*, Paris, 1599 and again 1600, 12mo; translated into English by Abraham Hartwell, London, 1599, 4to.

² *Ioannis Despauterii Ninivitarum, Grammaticae Institutionis, Lib. vii.* . . . Editio jam vice tertii intra decennium eliminata caeteris quibuscunque longe castigatior, cui Scotica præcipuarum vocum interpretatio adiuncta est, in usum Scholarum. Edinburgi, Execudebat Andreas Hart, 1621. 12mo.

It thus appears that this was the third edition since 1601.

There is a Vocabulary added to Lily's *Brevissima Institutio*, London, 1602, 8vo. The renderings in it are modern English and quite different from the Scots version.

Jocus,	a mow (1621) ; a sport or jest (1672). ¹
Capistrum,	a halter (1621) ; an horse halter (1672). Ein Maulkorb oder Halfter.
Balneum, Balneae,	the stoves. ² Ein Badt oder Badstube.
Culmen domus,	the rigging of a house.
Nugas,	a clatterer. Ein Unnutzerschuetzer.
Nugae,	clatters. Unnutze Reden.
Frit,	the black in the crop of corn. Ein Klein und gering Korn, welchs auff die reife Kornaher ist.
Aleo,	a dycer.
Vices,	course or turn about. Anstatt.
Tabes,	rotten and putrid blood and worsome.
Penum, penu,	a girmel of victual. Allerley Speyss und Tranck des menschen.
Colus,	a rocke. Ein Kunckel, Spinrock.
Ovile,	a sheep-folde. ³ Ein Schaffstat.
Cultus,	gold folye (1621) ; gold foylie (1672). ⁴ Getziert gebauet.
Genuinus,	the chaft tooth (1621) ; a chaft tooth (1672). ⁵ Naturlich angeboren. Item ein Backzan der nur am zweuentzigste oder 80 Jar eim Menschen vuascht.
Pituita,	flewme from the head descending or the roupe (1621) ; phlegm (1672). Rotz oder das Wasser im geblut der Schnopfe. Item in Gallinis das Pffitzen.
Macellum,	a flesh or fish market. Ein Speiss Marck, da man allerlei Speyss feil hat.

¹ The reference is p. 67, edition of 1621 ; p. 62, edition of 1672. The other examples are taken from the immediately succeeding pages, ending on p. 88 of 1621, and p. 81 of 1672.

² Jamieson misses this meaning.

³ In the Lowlands a stell or ree ; in the Highlands a fank.

⁴ The Scots translation is the rendering of Curio's "folium auri" quoted by Despauter. It so appears in his *Grammaticae Institutionis Pars Prima*, p. 68, Colon., 1625, 4to, and all later editions.

⁵ Jamieson's explanation of chaft-tooth is merely a jaw tooth. The above shows that he was not sufficiently specific.

Sinum vel sinus,	a bosom or bouked vessel. ¹
Cancelli,	tirleises (1621); stanchers or tirlises (1672). ² Eisen Geschrenck oder Trallien vor die Fenster.
Lemures,	bogils and ghosts. Die Nachgeister, Boese gespenst.
Coelites,	Saints in Heaven. Die Himmelschen oder die Hilgen.
Fori,	the hatches of a ship. Die Schiffbun Die Weite des Schiffs.
Sales,	merry and joyous words (1621); merry words or retorts (1672). Schimpfftrede, gute Schwenck.
Antiae,	Rowles of hair on the foreheads of women. Die vorderen Haarloeck der Weiber.
Ambages,	boutgates. Umbwege.
Scalae,	a standing ladder (1621); a stair or stand- ing ladder (1672). ³ Scala ein Leiter, Scalae plurale tantum. Ein Trappe oder Stege die man nit hinweg thein Kan. ⁴
Antae,	the jambs of a door or port. Die Seiten oder Poest an einer Thuren.
Naeniae,	a dool song. Ein Klagleid das man zu Gedachtnuss eines abgestorben singt & abusive ein ietlicher unnutzer Gesang.
Clitellae,	a pack saddle. Ein Sattel dae man Kork oder etvuas anders auffbindet.
Mappum,	a table cloth (1621); a board cloth (1672).
Scopae,	a besom. Ein Besem.
Crepundia,	children's puppets. ⁵ Allerlei Ding damit die Kinder spielen.

¹ Apparently Jamieson's byssum or bessum—A monster. In the English Vocabulary of 1602 it is rendered "A boule or a shippe for milke, or rim to drink of."

² *Supra*, Part i. p. 8. The English version of 1602 is "a lattice."

³ Hence we have a scale-stair, a straight or ladder-like stair, as opposed to a wheeling stair.

⁴ Pincianus, gives;—scale=stieg; scala=laiter. *Epitoma Grammaticae*, Augustae, 1513, 4to; and Jacob Heinrichmann gives the same translation in his *Grammaticae Institutiones*, fol., 24, recto, Hagenau, 1512, 4to.

⁵ In the English version of 1602, "Al maner of things that are given children in their infancy, such as coralles, swathing bandes, daggers, timbrels, and such like."

Comitia,	a convention for choosing magistrates—a parliament.
Bellaria,	Versammlung des Volcks. desert after meat. ¹
Mapalia,	Allerley Spyess die man zulerst mit dem Keesfursteller. country lodges (1621); country cottages ² (1672).
Patria,	a native country. Die Vatterlandt oder Der Heymer.

One of the drawbacks to Novimola's Despauter was the absence of paradigms. These were given in the Dunbar *Rudiments*,³ and it was no doubt assumed that the Accidence had been mastered before the larger grammar was taken in hand. The same practice prevailed in England. Lily's grammar,⁴ in its general features, resembled the abridgment of Despauter; like Despauter it had no paradigms, which were supplied in Colet's *Accidence*.⁵

Kirkwood was aware of the desirability of providing examples, and these are supplied in his *Grammatica facilis*,⁶ although not in his advanced grammar; and he was followed in this by Patrick Dykes in 1685, and Ruddiman in 1714 in their *Rudiments*, both of whom furnish paradigms.

6. Rudimenta Grammatices, Glasguae, 1696.

The Dunbar *Rudiments*⁷ seems to have been reprinted at Glasgow in 1696; but I have not seen a copy of the book, and I only know of the edition from a manuscript *Catalogue of books belonging to John Allan*,⁸ drawn up about the year 1707. There were doubtless others both earlier and later which have likewise disappeared.

¹ In the English version of 1602, "Iuncates."

² In the English version of 1602, "Sheepcotes, or small cottages."

³ *Supra*, Part i., p. 33.

⁴ *Brevissima Institutio, seu ratio Grammatices cognoscendae*, London, 1513, 4to, followed by innumerable editions.

⁵ *Supra*, p. 16.

⁶ *Supra*, Part i., p. 21.

⁷ *Supra*, Part i., p. 32.

⁸ There was a John Allan, a student at the University in 1706. *Munimenta Universitatis Glasguensis* iii. p. 184. This may be the author of the Catalogue and the same person who subsequently became schoolmaster at Campbeltown, and in 1719 minister of Row. Scott, *Fasti Ecclesiae Scoticanæ*, ii., p. 371.

7. Vossii *Rhetorica*,

Glasguae, 1696.

From John Allan's *Catalogue* it appears that the *Rhetoric* of Voss was also printed in Glasgow in 1696, but I have not been able to trace a copy.

As formerly mentioned one of the books, the printing of which was conceded to Sanders in 1672, was Vossii *Rhetorica*, and one of those which he printed between 1677 and 1680 was *Rhetorica*. Presumably this was Voss' *Rhetoric*, and if so there was thus a Glasgow edition earlier than that of 1696.

At this period the course of instruction at the Grammar School of Glasgow extended over five years, corresponding to which there were five classes in the school. On passing through the last the pupil was considered fit to enter the Humanity class in the university,¹ but in some cases a sixth year seems to have been added. In 1696 it was officially reported that the course of instruction and books in use were as follows :—

First year—*Rudimenta Etymologiae* ; Wedderburni, *Vocabula ; Dicta Sapientum e Graecis* Erasmo Roterodamo interprete ; Catonis *Disticha* ; Lili Monita *Paedagogica* ; Sulpitius *de Civilitate Morum* ; and upon Saturdays, *Rudimenta Pietatis* with a review of our Shorter Catechism with scriptural proofs.

The second year—The first part of Despauter's *Grammar* ; with Corderius and Erasmi *minora Colloquia* ; and on Saturdays, *Confessio Fidei, Latine*.

The third year—The second part of Despauter, with Terentius, Ovid's *Epistles, Tristia* ; Jonae Philologi *Dialogi* ;² Erasmus *de Civilitate Morum* ; and on Saturdays, *Dialogi sacri*.

The fourth year—A review of the second part of Grammar with the third ; Ovid *Metamorphoses* ; Erasmi, *majora Colloquia* ; and for Saturdays, Buchanan's *Psalms*.

The fifth year—The fourth part of Grammar ; Virgil, Quintus Curtius, Horatius et Sallustius ; and on Saturdays, Buchanan's *Psalms* ; Buchanani *Tragoediae*.

¹ Cleland, *Historical Account of the Grammar School*, p. 12. Glasgow, 1825, 8vo. The classes were named in the opposite order to the years. The First Class was of those in their fifth year. The Fifth Class was of those in their first year.

² There was an edition, Edinburgh, 1692.

Jonas *Philologus* prepared an Epitome of the *Rhetoric* Quintilian, Paris, 1547. There is a copy in the library of the University of Glasgow, the gift of Robert Boyd of Trochrigue.

The last year—*Rhetorica* Vossii ; *Lucan* ; *Commentaria* Caesaris ; *Buchanani Historia Scotorum* ; with a little insight in Greek ¹

The expression *Rudimenta Etymologiae* in the first year's course is not clear. According to the scheme suggested in 1685, "the Schollars of the Gramer School, the first yeir of their entry . . . shall be taught the common Rudiments," ² which no doubt refers to the *Dunbar Rudiments*. The *Rudiments* was, as previously explained, a general introduction to grammar and was not divided into Parts as in the full grammars, and corresponded to the *Introduction of the Eight Parts of Latin Speech*, prefixed to Lily's *Grammar*. Formal Grammar was divided into four Parts ; Etymology which treated of words singly ; Syntax or the construction of words in a sentence ; Prosody, which treated of the quantity of syllables ; and Orthography or the method of correct writing. Etymology, therefore, although the first Part of Grammar did not find a place in the Rudiments.

In the second year ³ the scholars "after having repeated over the Rudiments, are to learn the large halfe of the first part of Despauter's Grammar." Next year they took up the remainder of this part, and part of the second. In the fourth year they finished the third and fourth parts. In this way the *Dunbar Rudiments* was used as an introductory book for the youngest class, while Despauter's *Grammar* was used for the more advanced classes, each class taking a separate part. In the sixth year Voss' *Rhetoric* took the place of grammar.⁴ The *trivium*, it will be remembered, embraced grammar, rhetoric and logic—*lingua, tropus, ratio*. The latter was occasionally added to the school course, so that notwithstanding changes in method, the general idea of the course of education remained pretty much what it was in the Middle Ages.

Gerard John Voss (1577-1649), "the Prince of Grammarians," ⁵

¹ Visitation of the University of Glasgow, 21st August, 1696. *Munimenta Universitatis Glasguensis*, ii., p. 536.

² Cleland, *Historical Account of the High School*, p. 12. ³ *Ib.* p. 12.

⁴ In a list of "School books printed for and sold by William Brown, bookseller in the Parliament Close" at the end of Ciceronis *Epistolarum Libri*, iv., Edinb., 1720, 12mo, there occur Vossius' *Rhetorick*, and Kirkwood's *Rhetorick*.

⁵ Walch, *Historia Critica Latinae linguae*, p. 663. Lipsiae, 1761, 8vo, styles him "summus litterarum antistes." As to Voss and his *Rhetoric*, see Baillet, *Jugemens des Savans*, viii. Part ii., p. 171 ; ii. Part ii., p. 248. Amst., 1725, 12mo.

was successively a lecturer in the University of Leyden, head-master of the public school at Dort, Rector of the Theological College at Leyden, and professor in the Gymnasium at Amsterdam. When engaged in lecturing at Leyden he taught rhetoric, and upon his removal to Dort he published several small manuals in 1606, one of which, *Institutiones Oratoriae*, was devoted to this subject.¹ Many years afterwards the States of Holland, having resolved upon certain educational changes, directed that this manual should be used in the public schools. He revised it and issued it in 1621 as *Rhetorices contractae sive partitionum oratoriarum Libri V.*² It enjoyed great popularity, and passed through numerous editions, and became a recognised text-book in this country as well as abroad.³ His attention, having in this way been again directed to the subject, he was led to revise his work and it was issued in an enlarged and improved form as a third edition in 1630 as *Commentariorum Rhetoricorum sive Oratoriarum Institutionum Libri sex.*⁴ It is a monument of erudition, well arranged and clearly expressed, and, although bald in style, enjoyed a wide circulation.

It was also issued in an abridged form, *Elementa Rhetorica oratorii ejus partitionibus accommodata.*⁵

Whether it was the *Rhetorica contracta* or the *Elementa Rhetorica* that was reprinted at Glasgow in 1696 I am unable to say, but probably it was the latter, an edition of which had been issued at Aberdeen in 1631. This I have not seen and know it only from a reprint, London, 1663.⁶

¹ It was reprinted at Dordrecht in 1609, at Frankfort in 1617, and without place in 1616 in two volumes.

² Lugd. Bat. 1621, 8vo. (The dedication is dated 21st August, 1621.)

³ Oxonii, 1631, 1655, 1672, 12mo. Lugd. Bat., 1620, 1640, 1650, 8vo. Amst., 1655 and 1666, 8vo. Matriti, 1781, 12mo.

⁴ Lugd. Bat., 1630, 4to.

The preface contains the particulars upon which the above account is founded.

It appeared again as a fourth edition at Leyden in 1643, 4to; and as a fifth at Marburg in 1681. It was reprinted in the third volume of his collected works, *Opera Vossii*. Amstelod., 1695, fol.

⁵ Lugd. Bat., 1626 and 1634, 8vo; Middelb., 1640; Amst., 1646, 1655, 8vo; Cantabr., 1663, 8vo.

⁶ *Ger. Jo. Vossii Elementa Rhetorica, oratorii ejusdem Partitionibus accommodata Inque usum Scholarum Hollandiae & West-Frisiae primò edita; nunc autem post Aberdonense exemplar denuò recensita & multis in locis emendata.* Londini 1663, 12mo., pp. 48, A—C. 8.

In a note by the Printer to the Reader it is stated that this edition is printed after that issued at Aberdeen in 1631, but which apparently was printed at

The *Rhetorica Contracta* is a convenient, well arranged manual. The *Elementa* is a bald outline, little more than a catalogue of terms of art.

Rhetoric found a place in Dr Alexander Adam's *Principles of Latin and English Grammar* which was first published in 1772 ; and in James Moir's edition of Ruddiman's *Rudiments*.¹

Besides the Rhetoric of Voss, there was in the list of books which Sanders was allowed to print in 1672, the Rhetoric of Omer Talon or Andomarus Talaëus,² 1562, the friend of Ramus, which does not, however, seem to have been reprinted in Scotland. There were also several Scottish writers upon the subject. James Kirkwood, it will be remembered, published a compendium of Rhetoric³ which passed through two editions, and Robert Brown otherwise Robertus Brunus of Aberdeen, was the author of another which was twice printed.⁴

8. A plain and easy Latin Grammar . . . Serving both for Rudiments and Grammars now in use ; . . . By Hugh Crawford, A.M., School-Master at Mauchlaine.

Glasgow : Printed by James Duncan, Printer to the City of Glasgow, and to be sold at his shop and at Mr James M'euën's shop in Edinburgh north side of the Cross.

Printed in the year M.DCC.XXI.

Price bound 14 sh. Scots.

8vo, A—T 2. Title page, 1 + 148 pp.⁵

The author may have been the Hugo Crawford who was laureated in the University of Glasgow on 11th May, 1710 ; but

Leyden. In it the Greek accents were not marked. In the present, it is claimed, that this has been done and sundry typographical errors corrected.

The author's preface is dated Leyden, 1st September, 1636. He explains that this is an abridgment of his *Partitiones Oratoriae*, which was used in the higher classes in Holland and West Friesland, and which was published in 1621.

There are many later editions of the *Elementa*, e.g., Londini, 1724, 12mo.

¹ Edinburgh, 1779, 8vo. His chapter was founded on Mr Blackwall's *Introduction to the Classics*.

² *Rhetorica, e P. Rami . . . praelectionibus observata*, Paris, 1550, 4to ; Francof., 1590, 8vo ; and several other editions Reprinted Cantab., 1635, 12mo. See *Jugemens de Savans*, viii., Part i., p. 538. Amst., 1725. 12mo.

³ *Supra*, Part i., p., 31. Edinburgh, 1678 ; again *Id.*, 1696.

⁴ *Rudimentorum Rhetoricorum Libri V*, Aberdoniae, 1666, 1667, 12mo. There are copies of both in the library of the University of Glasgow.

⁵ There is a copy in the Library of the University of Glasgow. *Supra*, art i., p. 15.

it has been suggested that he had been formerly one of the doctors or classical masters in the High School of Edinburgh.¹

Thomas Ruddiman, writing in 1714,² mentions that some schoolmasters complained of the Latin grammars in general use because they were written in that language, while others defended the practice on the ground that the rules, when learnt, made a more lasting impression upon the mind. One of the sturdiest advocates for writing Latin grammar in English was Thomas Watt, A.M., who in 1704 published his *Grammar made Easie*.³ He was not, however, prepared wholly to depart from the old paths and took "Despauter's rules for a foundation, and endeavoured to keep as near them as might be, unless when obscurity, superfluity or deficiency required an alteration." His work is therefore a condensed and, to some extent, a re-arranged version of Despauter's metrical rules and with explanations in English. This was the method which had been adopted by the Port Royalists. Their view was that a Latin grammar should be written in the mother tongue of the pupil. They accordingly took Despauter's grammar, turned it into French, re-edited and partly re-wrote it, and published the version in 1644 as *Nouvelle Methode pour apprendre facilement la langue Latine*.⁴ The metrical rules are given in French, followed by a commentary as in the original work.

To avoid the language difficulty and to conciliate both sides Ruddiman wrote his *Rudiments* in Latin with an English version in a parallel column. His work was not an adaptation either of the Dunbar Rudiments or of Despauter, but a new one.

Crawford does not refer to Ruddiman's book, and it is possible he may not have seen it when he wrote, but it is more probable

¹ Hugh Crawford, M.A., "son to a merchant-burges of Edinburgh" was elected one of the doctors or classical masters of the High School of Edinburgh, 15th March, 1704. Steven, *History of the High School of Edinburgh*, Appendix, p. 88. He suggests that this was the author of the Grammar but he gives no authority for the statement. If so, he was no doubt the Hugo Crawford, who graduated at Edinburgh, 13th July, 1696. *Catalogue of Edinburgh Graduates*, p. 154.

² *Rudiments of the Latin Tongue*, Preface, Edinburgh, 1714, 12mo. *Supra*, Part i., p. 14.

³ *Supra*, Part i., p. 14. Mr John Hunter, minister of Ayr was also a strenuous advocate for writing Latin grammar in English. *Supra*, Part i., p. 14.

⁴ It passed through many editions. It was translated into English by Thomas Nugent, LL.D., and published at London, 1816, 8vo, 2 vols. It was also abridged, *Abrégé de la Nouvelle Methode*. Amst., 1720, 12mo.

that he had his own on hand before it was published and that he thought there was room for another. His opinion is decided that a Latin grammar should be written in the mother tongue and not in Latin. The grammars in use could not "be understood," he says, "without the Help of some previous Piece, commonly called Rudiments, whereby the Scholar's work is rendered Tedious and Intricate." His object, therefore, was to provide a book written in English and sufficient in itself for all purposes. The execution fell far short of the promise. The book is founded upon the common Despauter and, to some extent, apparently upon Kirkwood's works; but no paradigms are provided. The practice of embodying the rules in memorial verses is retained, English being substituted for Latin, with a commentary likewise in English.¹ The verses, however, are quite as uncouth as in Despauter and often more unintelligible.

All Names of *Males* are *Masculine*,
And *Females* Names are *Faeminine*.
When Names to either *sex* agree
Common to two, Then let them be

This seems to be a translation of Kirkwood's improvement of Despauter:—

Nomina cuncta marem signantia mascula sunt;
Et quae foemellam signant, muliebria ponas.
Commune est illud, quod sexum signat utrumque.²

The Port Royalists version is much on the same level:—

Tout Nom d'homme soit Masculin;
Tout Nom de femme Feminin
Lorsqu' un Nom est commun aux deux,
Son genre est Commun, non Douteux.

A boy could learn to repeat by rote either set of lines; but he

¹ John Clarke, of Hull, was another teacher who held strong views as to the absurdity of teaching the Latin tongue by means of a grammar written in Latin, and published *A new grammar of the Latin Tongue, comprising all in the art necessary for Grammar-schools*, London, 1733, 12mo. It is a useful and compendious handbook, with full paradigms, well displayed. It is written in English, but the author retains some of the Latin metrical rules for the genders of nouns. The book was somewhat roughly handled by Ruddiman.

² Hunter's version was:—

The Names of Men are Masculine,
And Women's Names are Feminine;
When Names to either Sex agree,
Then let their Gender common be.

which seems better than Crawford's.

would understand neither except by careful and exact explanation on the part of the teacher.

Crawford's next rule,

Some to the Termination fall ;
With such as Epicæne we call,

is still more embarrassing and would require a much fuller explanation than is vouchsafed by the author in his commentary. Ruddiman's explanation,¹ on the other hand, is clear and intelligible.

Dr Alexander Adam was of opinion that while it was impracticable to express with sufficient perspicuity the principles of grammar in Latin verse, there was some use in such aid where a great many exceptions to a general rule had to be committed to memory, and that the verses used should be in Latin not in English.²

Crawford's Syntax follows the old lines, but the explanations are pertinent and well put.

Although his grammar is not of value as an exposition of the science of grammar it is of importance as an evidence of the interest that was being taken in the subject and of the efforts that were being made by country schoolmasters for the improvement of education. Mauchline was a small town in an agricultural district, and the fact that there was a sufficient number of boys to form a Latin class, and that the master was anxious that they should be taught according to the best method, indicate that there must have been considerable enthusiasm for education and that the standard aimed at was high.³ Latin was efficiently taught in the numerous grammar schools of Scotland ; but it has been said that it was not taught in ordinary parochial schools in the seventeenth and eighteenth centuries. This is true as regards some schools but there is no doubt that in very many of them the education was excellent and

¹ *Rudiments*, p. 6.

² Preface to the fourth edition of *Principles of Latin and English Grammar*, Edinburgh, 1793, 8vo.

³ The Kirk-Session of Mauchline, on 4th December, 1692, "enacted that there should be no school w'in ane mile of Mauchlein toun, and that all who would keep schools w'in the paroch should come to the minister, and be tryed of their qualifications and fitnes for that office, and crave libertie to trade from the Session."

included Latin.¹ Robert Blau, whose school books have been already mentioned,² was schoolmaster at Calder, before he became one of the doctors in the Grammar School of Edinburgh. John Tran, who was appointed one of the Regents or Professors of Philosophy in the University of Glasgow in 1669, was formerly parish schoolmaster of Eaglesham and a good Latin scholar³; and many other schoolmasters from ordinary parish schools were advanced to the position of Regents in the Universities or doctors in the grammar schools.

9. Index to the Etymology of Mr. Ruddiman's Grammar.
Glasgow, 1733, 8vo.

This I have not seen and know it only from Ruddiman's list.⁴ It was no doubt similar to Kirkwood's Index to the first part of his Grammar, which was a translation of all the words and sentences occurring as examples.

The author was James Purdie,⁵ Rector of the Grammar School of Glasgow. He was formerly at North Berwick, and was elected Rector, 10th October, 1731, and resigned 9th April, 1756, with an annuity of £40 a year. He did not, however, live to enjoy it long, as he died near Edinburgh upon 22nd August, 1757,⁶ the same year in which Mr. Ruddiman died.⁷

He was one of Professor Robert Simson's intimates, and a

¹ In every Parish there is a school set up by Act of Parliament, whose Master has a Salary from the Public, and the Scholars allow him some small Matter quarterly. In Country Schools they teach Writing and Arithmetic and reading *English*, and in some *Latin*. In the Royal Burghs they teach *Latin* and *Greek*, and have tolerable Salaries; besides that each Scholar gives 2s. or 2s. 6d. a Quarter; and in these schools they teach nothing else, having *English* and Writing Schools besides in all Places where they have Grammar Schools." Chamberlayne, *Magnae Britanniae Notitia*, p. 528, London, 1708, 8vo. *Ib.*, p. 433, 1723 and 1729, 8vo.

² *Supra*, Part i., p. 13.

³ *Munimenta Universitatis Glasguensis* iii., p. 393. *Life of James Wodrow*, p. 16. Edinburgh, 1828, 8vo.

He died in 1704. His library was sold within the University in September of that year:—*A Catalogue of Books consisting of Divinity, Philosophy, History, etc., which belonged to the deceased Mr John Tran, Professor of Philosophy in the University of Glasgow. To be sold within the said University, on the 15th September inst.* See *The Edinburgh Gazette*, 4th September, 1704.

⁴ *Bibliotheca Romana*, p. 63.

⁵ James Purdie graduated M.A. at the University of Edinburgh in 1705. *Catalogue of Edinburgh Graduates*, p. 177. This is probably the Rector.

⁶ *Glasgow Journal*, 29th August, 1757. He is styled "the learned Mr. James Purdie." *Scots Magazine*, xix. (1757), p. 438.

⁷ *Ib.*, p. 54.

member of his club. The club in 1744, according to Alexander Carlyle's account,¹ "consisted chiefly of Hercules Lindsay, Teacher of Law, who was talkative and assuming; of James Moore, Professor of Greek on the death of Mr. Dunlop, a very lively and witty man, and a famous Grecian but a more famous punster; Mr. Dick, Professor of Natural Philosophy, a very worthy man, and of an agreeable temper; and Mr. James Purdie, the Rector of the Grammar School, who had not much to recommend him but his being an adept in grammar. Having been asked to see a famous comet that had appeared this winter or the following, through Professor Dick's telescope, which was the best in the College at that time, when Mr. Purdie retired from taking his view of it, he turned to Mr. Simson, and said, 'Mr. Robert, I believe it is *hic* or *haec cometa*, a comet.'"

His salary as Rector was only £40 a year, with the wages of 4s. per quarter for each scholar in his own class²; and to supplement his income, like most schoolmasters of the time, he kept boarders. "He had," says Carlyle, half a dozen or eight boarders, for whom his daughters kept a very good table, insomuch that I was often invited to dinner, and became intimate in the family."³ It was the general custom for schoolmasters, both burgh and parochial, to take in boys as boarders. Alexander Fergusson, master of the school at Colington, "three short miles from Edinburgh, an agreeable place, fine air," advertised in 1742,⁴ "Good accommodation for Boarders." In 1765, Mr. William Bald, one of the doctors or under-masters of the Grammar School of Glasgow, was appointed Rector of the Grammar School of Hamilton. This was officially announced with the addition that "The Rector has a large, well-aired, commodious house, very proper for the accommodation of boarders."⁵ Mr. Oman, schoolmaster at Peebles, taught young gentlemen the Greek, Latin, and French languages; also writing, arithmetic, geography, and mensuration; and took in "boys as boarders at the moderate rate of £12, 12s. a year for bed, board, washing, and education."⁶ Mr. Gibson, master of the Perth Academy, had genteel accom-

¹ *Autobiography of Alexander Carlyle*, p. 81.

² Cleland, *Historical Account of the Grammar School of Glasgow*, p. 16.

³ *Autobiography*, p. 101.

⁴ *Scots Magazine*, Advertisement Sheet, August 1742.

⁵ *The Glasgow Journal*, 9th and 16th May, 1765.

⁶ *Ruddiman's Weekly Mercury*, 26th August, 1779.

modation for young gentlemen, superintended their studies and boarded them for £6 per quarter.¹ We get a curious glimpse of boarding arrangements, at a much earlier period, in a letter from Robert Seton to Alexander, sixth Earl of Eglinton. The Earl had some intention of sending his sons to board with the schoolmaster of Prestonpans,² and had instructed Seton to make inquiries and to report. This he did, and writes from Tranent on 9th April, 1620:—"I haif at lenth spokin with the scoulmester in the Panis, quaha dois assur me that hes preceis price of his buirders sitting at tabill is tuo hunder merk ; and those that sittes at the fuit of the tabill faires als weall as those at the heide, and so most pay no lesse ; so this will cum to nyn hunder merk a year. The tearme advanscit at the entrie, and everie on of the scollers a dolor in the quarter, besydes clothes wasching and Candelmes candell silver ; zour lordship must also send tuo bedding of clothes with them."³

About 1680 Robert Muir of Monkwood, in the parish of Maybole, was boarded with John Muir, Provost of Ayr, where he had as fellow boarders the eldest sons of Sir John Kennedy and Sir Godfray M'Culloch. The Provost not only lodged him but also provided him with clothes, washing, and mending, paid his school wages, Candlemas offering and school book, furnished him with periwigs, and whatever else was required including medicines when he was sick. For the board he was allowed £10 Sterling per annum and £10 further for the other disbursements.⁴ It will

¹ *The Glasgow Mercury*, 5th September, 1782.

² Prestonpans was a notable school. The grammar school was founded and endowed by Mr. John Davidson, the poet and minister of Prestonpans, and Alexander Hume, the grammarian (*supra*, Part i. p. 9, was brought from the High School of Edinburgh in 1606, to take charge of it. He seems to have resigned the mastership about 1615, when he was called to the grammar school of Dunbar. See M'Crie, *Life of Andrew Melville*, pp. 383, 473, 495.

An earlier schoolmaster, John Fian or Cunningham, was burnt for witchcraft on the Castle Hill of Edinburgh in 1591. He had acted as clerk or secretary of meetings of witches at North Berwick Kirk and elsewhere. See Pitcairn, *Ancient Criminal Trials*, i. Part 3, p. 209; Calderwood, *History of the Kirk of Scotland*, v. p. 116; Chambers, *Domestic Annals of Scotland*, vol. i. p. 212; *News from Scotland declaring the Damnable Life and Death of Doctor Fian, a notable sorcerer*, London, 1591, 4to. Reprinted for the Roxburgh Club, London, 1816, 4to; Pitcairn, *supra*, and vol. i. p. 213; Law's *Memorials*, pp. xxx. *sqq.*, Edinburgh, 1818, 4to.

³ *Historical MSS. Commission*, 10th Report, Part i. p. 45; Fraser, *Memorials of the Montgomeries*, i. p. 214.

⁴ Paterson, *History of the County of Ayr*, ii., p. 370. Paisley, 1852, 8vo.; *Histories of the Counties of Ayr and Wigton* ii., p. 441, Edinburgh, 1864.

The boarding of a boy in Glasgow in 1650 was £180 Scots or £15 Stg. per annum. *The Caldwell Papers*, i., p. 104, cf. pp. 101, 106.

be remembered that the Earl of Stair sent his eldest son to board with the schoolmaster of Linlithgow.¹ One of Rector Purdie's boarders was Sir William Gordon, K.B., who was with him for two or three years before 1745.²

10. Grammatical Exercises in the Latin Tongue.

Glasgow, 1759, 12mo.

This I have not seen. There was a copy in Professor James Moor's library.³

It was no doubt a reprint of *Grammatical Exercises . . . adapted to the method of Mr. Ruddiman's Rudiments* which was published at Edinburgh in 1755, 8vo. These *Exercises* were originally composed by Mr. William Turner, Master of the Free School at Stamford, and published in London in 1713, under the title *Exercises to the Accidence*.⁴ They were prepared for use with Lily's *Grammar*, and enjoyed great popularity. Ruddiman rearranged them to suit his own *Rudiments*, and they were used in many schools until a comparatively recent date. As late as 1812 James Sinclair, teacher, Burntisland, published a *Key* to them.⁵ There was another Glasgow edition published in 1787,⁶ and others which I have not seen. I have a copy of an Edinburgh edition of 1791⁷ which was presented as a Grammar School prize in 1798 to John Hopkirk, probably a son of James Hopkirk of Dalbeth. It is said to have been "carefully printed from the last edition that was revised and corrected by the late Mr. Thomas Ruddiman."

The *Exercises* consist of English sentences with the Latin words in a parallel column, nouns being put in the nominative case; adjectives in the masculine gender; and verbs in the

¹ *Supra*, Part i., p. 28.

² Carlyle, *Autobiography*, p. 104.

³ *Bibliotheca Mooreiana*, No 1961.

⁴ A third edition appeared, London, 1723, 8vo; a fourth in 1728, and a fifth in 1736.

⁵ *A Key to the Grammatical Exercises*. Edinburgh, 1812, 12mo. It need hardly be said that it is a rare book, as most school books are. I have a copy. He also translated the *Satires of Juvenal*. Edinburgh, 1814. *Ib.* 1815, 12mo.

⁶ Glasgow (A. Chapman and A. Duncan), 1787. See *Glasgow Mercury*, 15th August, 1787.

⁷ Edinburgh: Printed for Dunlop & Wilson, Glasgow, and Silvester Doig, Edinburgh, 1791, 12mo.

Dunlop & Wilson were well-known booksellers in the Trongate. They for a long time supplied the prize books for the Grammar School. Strang, *Glasgow and its Clubs*, p. 83, 3d edition.

There was an edition Edinburgh, 1782. *Glasgow Mercury*, 29th Aug., 1782.

perfect of the infinitive mood either active or passive as the examples require. The sentences were arranged under the various rules and the pupil had to render the English into the appropriate Latin. The book was an excellent one of its kind. Mr. Turner's sentences were taken from the classics, and were selected with the view of providing moral instruction as well as material for correct latinity. From this point of view they were much more interesting than the somewhat inane sentences that figure in T. K. Arnold's *Latin Prose Composition*.

A rival to the *Grammatical Exercises* was John Mair's *Introduction to Latin Syntax*¹ which was published in the same year, and was likewise intended as "an exemplification of the Rules of Construction, as delivered in Mr. Ruddiman's Rudiments." It was much upon the same plan and likewise enjoyed great popularity. It was in general use in my day. I had it in one school and Arnold in another. Both Mair's *Introduction* and the *Grammatical Exercises* were edited and revised by Dr. A. R. Carson, Rector of the High School of Edinburgh.²

11. Introduction to Latin Crammar, by James Barr, A.M., Rector of the Grammar-School of Glasgow. Glasgow, 1763, 12mo.³

12. A Practical Grammar of the Latin Tongue adapted to the rules of Mr. Ruddiman's Rudiments, by James Barr, A.M., Rector of the Grammar-School of Glasgow.

Glasgow, Printed for the Author, 1770, 8vo, pp. viii. + 251.

James Barr was appointed Rector of the Grammar School in April, 1756, upon the resignation of Mr. James Purdie.⁴ He had studied for the church and was then a preacher of the Gospel in Glasgow.⁵ As he was a Master of Arts it is probably he who graduated at Glasgow 1735.⁶ He resigned office in 1782 with an annuity of £60 a year, and died on 27th April, 1785. He built a large tenement on the west side of High Street, opposite the

¹ *Supra* Part i, p. 16.

² Edinburgh, 1817, and subsequent dates. I have a copy of the edition of 1820 given as a Glasgow Grammar School Prize.

³ There was a copy in Professor Moor's library. *Bibliotheca Mooreiana* No. 1966.

⁴ *Glasgow Journal*, 12th April, 1756.

⁵ Curiously, his successor, Daniel M'Arthur, was likewise a preacher of the Gospel in Glasgow. He published *The Church of Rome the Mother of Abominations; a Sermon delivered in the Blackfriars Church*. Glasgow, 1778, 8vo.

⁶ Innes Addison, *Roll of Graduates*, p. 35. He was from the parish of Lesmahagow. The names of a number of farmers bearing the name "Barr" appear on the poll tax rolls of that parish in 1695. See Greenshields, *Annals of the Parish of Lesmahagow*, pp. 178, 182, 183, 184. Edinburgh, 1864, 4to.

Blackfriars Church, on the site of the old Grey Friars Monastery, long known as Barr's Land."¹ In a niche in the centre of the front he placed a bust of Cicero, on the pedestal of which he inscribed in capital letters "M. T. Cicero."

The Grammar, as the title page bears, professes to be "adapted to the rules of Mr. Ruddiman's Rudiments," and in so far as Syntax is concerned it was intended to be used along with the *Rudiments*, but otherwise it was complete in itself and was not dependent upon any other book. It is entirely in English, and is written in narrative form, except in the case of the author's "Remarks on Syntax," which are by the way of question and answer. It is clear and succinct, and easy to follow. It is not encumbered with philosophical remarks or philological comments, but gives all that a schoolboy, at least in the lower forms, requires to learn. The paradigms are full and convenient. The section upon etymology is, however, out of all proportion to an elementary work, and not sufficiently scientific for a complete Grammar. For this the author apologises. "Some, perhaps," he says, "may think the etymology² too full; but of all the parts of Latin Grammar this can least bear to be abridged, because it contains forms of all the regular flexions, and the exceptions to them. If these are not learned early and with care, boys must often be at a loss, and perhaps never acquire that knowledge of words, which is absolutely necessary to the understanding of the language. In this Grammar the etymology is drawn up in the form of a Vocabulary, that it may supply the place of one, and being put into boys hands immediately after they have learned the declensions in the Rudiments, may be often repeated in tasks overnight; for in the business of education it can hardly be conceived, without experience, how much depends upon frequent and careful repetition." That frequent repetition is necessary in the work of elementary education will not be disputed, and that

¹ He appears in Tait's *Glasgow Directory* for 1783, as "James Barr, late Rector of the Grammar School, High Street."

² Etymology is that part of Grammar which treats of the rules relating to the accidents and parts of individual words, as for instance the genders and declensions of nouns, the conjugations of verbs, &c. Scioppius *Grammatica philosophica*, p. 5. Aug. Vind., 1712, 8vo. That part of grammar which treats of words is called *Etymology* or *Analogy*, Adam's *Principles of Latin Grammar*, p. 4. Despauter's definition was more in accordance with the modern use of the word. Etymology, he says, is the science which explains the true origins of words with their other accidents. This is the view of G. J. Voss. Etymology, he says, is that part of grammar which explains the origins of words. Analogy explains their differences. *Aristarchus*, i. p. 369. Amst., 1662. 4to.

boys should have an accurate knowledge of the inflexions of nouns and verbs goes without saying; but opinions will differ as to whether it is necessary that they should be required to commit to memory all the minute rules of gender which grammarians have evolved and all the nouns that exemplify or depart from those rules. Such an exercise certainly provides a *copia verborum*, but a large proportion of the words in Mr. Barr's list are seldom met with, and a pupil's time and pains would be more profitably spent in acquiring a knowledge of words of more common occurrence.¹ The Syntax is followed by a chapter on Grammatical Forms, a Treatise on Prosody, and some useful tables.

Two years after Mr Barr's venture, Dr Alexander Adam, the Rector of the High School of Edinburgh, published his well-known grammar.² It is a more scientific and thoughtful work than Barr's but the latter was the earlier in the field, and made use of the plan which Adam subsequently followed. Both wrote in English. "The Rules are all exprest in English," says Mr. Barr, "as being the speediest way of communicating the principles of a language, which must be supposed as yet unknown." Dr Adam writes very much to the same effect in the preface to his fourth edition. Both associated the teaching of English grammar with that of Latin grammar. "The knowledge of the Latin Tongue," says Mr Barr, "is not only a key to the Sciences but leads to a more perfect understanding of English." "The English language," says Dr Adam, "has received its greatest improvements from those who were masters of classical learning; and perhaps it cannot be thoroughly understood, without some acquaintance with the Latin." The plan of the two books, as regards Etymology, is much the same. Dr Adam, however,

¹ John Clarke, the master of the Grammar School at Hull, speaking of the uselessness of learning lists of out-of-the-way words and other customs, says, "till some Body shall have the Goodness to inform me better, I shall take the liberty to set them down for one of those vain Amusements that some have found out to make Boys spend their Time at School to no purpose." *An Essay upon the Education of Youth in Grammar Schools*, p. 21. London, 1720, 8vo.

² *The Principles of Latin and English Grammar*. Edinburgh, 1772, 8vo. The copyright was given to the Society of Burgh and Parochial Schoolmasters of Scotland by Dr. Walter Adam, the author's son. The third edition appeared in 1786, the fourth in 1793, the fifth in 1798, the sixth in 1805, the ninth in 1816, the eleventh in 1823, and the thirteenth in 1832. It was also repeatedly reprinted in Boston (Mass.), and other places in the United States of America. See *Account of . . . Alexander Adam* (by Alexander Henderson, N. and Q. 4th S. vi. 286), p. 35, Edinburgh 1810, 8vo; Steven. *History of the High School of Edinburgh*, Appendix p. 55; "Memoir of Alexander Adam" in *The Glasgow Magazine*, i., p. 34, Glasgow, 1811, 8vo.

adds after the examples of each declension a list of words that may be declined in the same way. These lists, were no doubt given for the purpose of providing the pupil with a vocabulary, but they are too long, and many of the words might have been omitted without loss. Barr, as we have seen, intended that Ruddiman's Syntax should be used along with the additions he provided. Adam gave an entirely new Syntax. It is too full for an elementary Grammar, but is an excellent treatise on the subject. The explanation of the Figures of Syntax is founded upon Ruddiman,¹ and is much the same in both books; and the chapter on Prosody is also necessarily similar in both, although Adam's is considerably the longer of the two. Both give an analysis of English verse.² Dr Adam prints, as an Appendix, Ruddiman's Latin Rules for genders and quantities. Mr. Barr concludes his prosody with "Some easy general Rules for Quantity."

I do not mean to suggest that Dr Adam copied from Mr. Barr or borrowed his plan. He worked, I have no doubt, quite independently; but it is to Mr. Barr's credit that he adopted a method which the work of so eminent a grammarian as Dr Adam showed was a right one.

13. The Rudiments of the Latin Tongue . . . By Tho. Ruddiman, M.A. The eighteenth edition³ corrected.
Glasgow: Printed by William Smith. For John Tait and James Duncan, Booksellers. 1774, 8vo. pp. viii. + 104 + 32.
14. The Rudiments of the Latin Tongue . . . By Tho. Ruddiman, M.A. The twentieth edition, corrected.
Glasgow, 1777, 8vo.⁴
15. The Rudiments of the Latin Tongue . . . By Tho. Ruddiman, M.A. The twenty-fourth edition, corrected. . . .
Glasgow, Printed by William Smith, for Robert Farie, Bookseller,⁵ 1782, 8vo. pp. xviii. + 144.

¹ *Grammaticae Latinae Institutiones*, Part ii., p. 332, Edinburgh, 1731. Part ii., p. 127, *Ib.* 1771.

² The seventh edition of the Port Royal Grammar (Paris, 1667, 8vo), contained a chapter on the rules of French poetry, and the twelfth (Paris, 1761, 8vo) was furnished with a general Index of Words.

³ In 1782, C. Elliott, Parliament Square, Edinburgh, published what he termed "the eighteenth genuine edition," carefully corrected by a gentleman in Edinburgh. Price 10d. bound. *Glasgow Mercury*, 29th August, 1782.

⁴ There was a "twentieth genuine edition," Montrose, printed by Da. Buchanan, for . . . Jas. Duncan, Glasgow, 1790.

⁵ His shop was at Yorick's Head, Salt-mercat. His name appears in *Tair's Directory* for 1783-84, and in that of 1789.

Ruddiman's *Rudiments*, as formerly mentioned,¹ originally appeared in 1714. It soon established itself as the most popular grammar in the country, and passed through fifteen editions before the author's death in 1757. According to Reisig² the grammar of "the Englishman" Ruddiman is a solid and valuable work which, in certain respects, has not yet been superseded, and is still the standard work in England. This being so, it might seem strange that no edition was published at Glasgow until sixty years after its first publication; but the question of copyright stood in the way.³

The editions of 1774 and 1777 were simply reprints of the standard text. In 1779 an edition appeared at Edinburgh with notes and additions by James Moir, teacher of languages in that city.⁴ This may have induced the Glasgow publisher to add something to the next edition, as in that of 1782 there is prefixed "an Essay on the art of conducting youth in Grammatical Studies." It is signed "Grammaticus," and is said "to have been never before printed." There is no indication of authorship, but it may perhaps have been by William Gordon, a well known teacher of arithmetic and book-keeping in Glasgow, who also devoted part of his time to teaching the classics, and in 1783 published, at Glasgow, a translation of the first six books of Livy, which was printed for and sold by William Smith, who was the printer of the Grammar and Essay.⁵

The author mentions (p. 17) that boys "are generally put under the care of a teacher of humanity at eight years of age; and by applying for the first year, only six hours a-day, and seven hours a-day afterwards, may, in the course of five years, under a skilful master, be able to translate any prose author from Latin to English or from English to Latin at sight."

The course of study, recommended by the author of the

¹ *Supra*, Part i. p. 14.

² *Vorlesungen ueber lateinische Sprachwissenschaft*, i. pp. 39, 44. Berlin, 1881, 8vo; see also Haase, *Vorlesungen ueber lateinische Sprachwissenschaft*, i. p. 28. Leipzig, 1874. *Supra* p. 30.

³ Ruddiman had a grant of copyright for fourteen years from 5th May, 1756. Mrs. Ruddiman, his widow, enjoyed the copyright until her death in 1769.

⁴ *Supra*, p. 38. He was the author of *The Scholar's Vademecum, or a new Dictionary, Latin and English*, Edinburgh, 1775, 8vo. Again, *ib.* 1805, 8vo. He was opposed to the method of teaching etymology by means of the long lists of words already alluded to. He gave the list of irregular nouns prepared by Ruddiman, and referred boys for the others to his *Vademecum*.

⁵ He recommends (Preface p. 1) the use of literal translations by boys in order "to facilitate and promote their progress and to enlarge their ideas of English as well as Latin phraseology." Similar suggestions occur in the *Essay*.

Essay, was, as a beginning, an explanation of the parts of speech and the declensions of nouns and adjectives verbs, and other roots and exercises in Syntax. When a supply of words has been obtained for which Mair's *Vocabulary*, he says, is suitable, they are to try the short sentences at the end of the *Rudiments*. Then Cordery, with a literal translation, and next Eutropius, with a similar translation—the pupils translating from Latin into English and from English into Latin. Then they are to take up Cæsar—but without a translation. Along with Cæsar, lessons in geography are to be given. Next follow Sallust and Virgil. Before the *Æneid* is begun the nature of an epic poem is to be fully explained. Passages of the classics are to be committed to memory and repeated in public, so that the pupil may acquire confidence, a graceful pronunciation, and an agreeable manner. Lastly, Horace, Livy, Terence, and Cicero are to be read. The making of Latin versions is to be practised. After the class has read Cordery, an hour should be spent every morning in making Latin from Mair's or Clarke's *Introduction*.¹ Four times a week a sentence in English is to be given for translation and to be gradually increased in difficulty. The translation of Latin into English is to be prescribed once a week to give the pupils practice in English.²

There is no information as to the number of copies in any of these editions. The last edition under the copyright, the seventeenth, published in 1769, consisted of 20,000, and a pirated edition, printed at Edinburgh in 1770, consisted of 10,000 copies.

16. Ruddiman's *Rudiments of the Latin Tongue and Grammaticæ Latinæ Institutiones*, with the exception of the parts not taught, in which the *Rules de Generibus Nominum* are literally translated By John Dymock.

Glasgow ; Printed at the University Press, for Andrew and John M. Duncan . . . 1819.

pp. iv + 189.

The title-page explains the nature and object of this publication which was several times reprinted both in Glasgow and Edinburgh³

It is evidence of the excellence of Ruddiman's work that after

¹ *An Introduction to the making of Latin*. London, 1733. 12mo, eighth edition. The eleventh edition appeared in 1740. *A Supplement* was published after Mr. Clarke's death. London, 1740, 12mo.

² With this compare Ruddiman's "Remarks on Clarke's Translations" in Love's *Animadversions on Trotter*, p. 107 (Edinburgh, 1733, 8vo).

³ There was an earlier edition, Glasgow, 1812; and a later, Edinburgh, 1829, printed at the University Press.

the lapse of more than a century it should still have been accepted as the most useful book of the kind that had appeared. An edition was kept in stereotype by the Edinburgh University Press. Others were issued at Aberdeen.¹ It was also edited by Dr John Hunter, of St. Andrews, and passed through at least seven editions.²

A few years after Dymock's edition had appeared, the *Rudiments* were re-edited by Mr George Ferguson and published as *Rudiments of the Latin Language*, for the use of the Edinburgh Academy,³ and in this form the old work has held its own down to the present time.⁴ In the last revision of the Academy *Rudiments* by Dr James Clyde the original features of Ruddiman's work have almost disappeared.

Mr. John Dymock was formerly Rector of the Grammar School of Kelso. He was appointed Rector of the Grammar School of Glasgow on the death of Mr. Daniel Macarthur in 1808,⁵ and held office until 1834,⁶ when he retired. He died four years afterwards, on 9th November, 1838, aged 71. He was an excellent classical scholar, and published valuable school editions of Cæsar and other classics.⁷ He prepared a useful abridgment of Ainsworth's *Latin Dictionary*, which was repeatedly reprinted⁸ and in conjunction with his son, Thomas Dymock, M.A., compiled a *Classical Dictionary*.⁹ In recognition of his services to classical learning and of his eminence as a teacher the University of Glasgow conferred upon him the degree of LL.D. in 1829.

¹ Aberdeen, 1803, 1806, 8vo. Edited by Dunn.

² The first edition appeared at Cupar in 1820; the third in 1823; the sixth in 1837.

³ Edinburgh, 1826, 12mo. The second edition appeared in 1828; the fifth in 1838; the ninth in 1845, and in this shape it continued to be issued until 1879, when it was superseded by *Rudiments of the Latin Language for the use of the Edinburgh Academy*. By James Clyde.

⁴ Ruddiman's *Rudiments* was edited by William Mann and published at Baltimore, 1855, 12mo.

⁵ *Glasgow Journal*, 1st and 15th April, 1808.

⁶ He had a presentation on the occasion of his retiral. See *Scottish Guardian* 21st October, 1834.

⁷ His Cæsar and Extracts from Ovid's *Metamorphoses* were very favourably reviewed in the *Edinburgh Magazine*, 1817. Part i., p. 45. He also edited the first five Books of Livy, and likewise Sallust and Virgil.

⁸ The second edition was published at Glasgow in 1830, and, after several intermediate editions, it appeared again, London, 1882, 8vo.

⁹ *Bibliotheca Classica: or, a Classical Dictionary, on a plan entirely new*. London, 1833, 8vo, but printed at Glasgow by Edward Khull, printer to the University.

Solutions of Physical Problems. By ANDREW GRAY, LL.D.,
F.R.S., Professor of Natural Philosophy in the University
of Glasgow.

[Read before the Mathematical and Physical Section, 21st March, 1906.]

I. *The Attractive Force between Two Halves of a Sphere of Matter of Density symmetrical about the centre.*

1. The problem of finding the force required to separate two hemispheres of a sphere of uniform density, held together by the gravitational attraction of the matter composing them, was proposed by the late Professor Tait, and solved by him in a very simple manner by an ingenious application of hydrostatic principles.¹ At first sight the solution of the problem by direct integration, which involves obviously the evaluation of a sextuple integral, seems likely to be tedious if not difficult. If, however, the integration is properly arranged, the result is easily obtained, and I shall, in what follows, exemplify this by three discussions of the problem (somewhat generalised), the second of which starts from a curious theorem of the attraction of concentric spherical shells, and may not be without interest on account of the considerations involved. I shall also explain the hydrostatic method, and give one other indirect method which depends on Gauss's well-known theorem of the surface integral of normal force taken over a closed surface drawn in a field of gravitational attraction.

The problem proposed is of physical interest from the proof which its solution affords that the cohesion of ordinary matter cannot be due to the gravitational attraction of the parts of the body, on the supposition at least of uniform or of finite and continuously varying density of the body, considered as holding down to the smallest parts of which it may be conceived as composed.

2. I shall here consider the more general problem of the gravitational attraction between two hemispheres of a sphere of radius a ; in the first place when the density at distance r from the centre is $b - cr$, and again when the density is a function $f(r)$ of

¹ Proc. R.S., 1875.

the distance from the centre. The former case will give a better approximation to the attraction between two hemispheres of the earth, to find which was one object of Tait's calculation. Here b is clearly the density of the sphere at the centre, and $b - ca$ the density at the surface.

We may, for purposes of comparison afterwards, find first the mean density of the sphere. If this be ρ_m , we have to find ρ_m from the equation

$$\frac{4}{3} \pi \rho_m a^3 = \int_0^a 4\pi r^2 (b - cr) dr = \frac{4}{3} \pi ba^3 - \pi ca^4 \quad (1)$$

Therefore

$$\rho_m = b - \frac{3}{4} ca \quad (2)$$

3. Reverting now to the problem proposed, we calculate first the attraction of the smaller concentric sphere of radius r on a unit particle at any point P (see Fig. 1) on its surface, and resolving

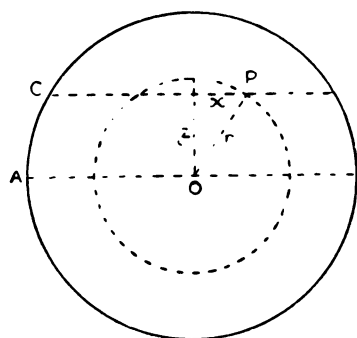


Fig 1

this at right angles to a diametral plane, find the attraction normal to a parallel plane through the point, exerted by this internal sphere on a particle of unit mass. We shall take the attraction between two particles of unit mass—the constant of gravitation—as unity. This, of course, gives a special value, what may be called the astronomical value, to the unit

of mass. It will only be necessary to multiply the result obtained by the proper value of this constant, to find the force in any chosen system of units.

The mass of the sphere of radius r is

$$\int_0^r 4\pi r^2 (b - cr) dr = 4\pi r^3 \left(\frac{b}{3} - \frac{cr}{4} \right) \quad (3)$$

where the r under the integral sign is as usual taken as the varying value, and the r displayed as the superior limit, and written on the right hand side, as that denoting the radius of the sphere considered.

Since the attraction A of this sphere on an external particle is

the same as if the whole mass were collected at the centre we obtain by (3), taking the mass of the particle as unity

$$A = 4\pi r \left(\frac{1}{3}b - \frac{1}{4}cr \right); \quad (4)$$

and if z be the distance of the point considered from the diametral plane, the component of A in the direction of the normal is Az/r . By (4)

$$A \frac{z}{r} = \frac{4}{3} \pi bz - \pi cz \sqrt{x^2 + z^2}$$

if x be the distance of P from the axis of the diametral plane, as shown in Fig. 1, so that $r^2 = x^2 + z^2$.

Now considering a thin slice of the sphere, of thickness dz , containing P and taken parallel to the diametral plane, we have for the mass per unit area of this slice at P the value $(b - c \sqrt{x^2 + z^2})dz$. Hence the force perpendicular to the diametral plane on this mass is

$$\left(\frac{4}{3} \pi bz - \pi cz \sqrt{x^2 + z^2} \right) (b - c \sqrt{x^2 + z^2}) dz,$$

and the attraction in the same direction on a ring of the slice of radius x and breadth dx , is this expression multiplied by $2\pi x dx$. The radius, r' say, of the slice is $\sqrt{a^2 - z^2}$. Hence the total attraction normal to the diametral plane exerted on the slice is

$$\begin{aligned} 2\pi^2 z dz \int_0^{r'} \left(\frac{4}{3} b - c \sqrt{x^2 + z^2} \right) (b - c \sqrt{x^2 + z^2}) x dx \\ = 2\pi^2 z dz \left\{ \frac{2}{3} b^2 (a^2 - z^2) - \frac{7}{9} bc (a^3 - z^3) + c^2 (a^2 - z^2) \left(\frac{1}{4} (a^2 - z^2) + \frac{1}{2} z^2 \right) \right\} \end{aligned}$$

The whole attraction F on the hemisphere is obtained by integrating this expression from $z=0$ to $z=a$, and thus we get finally

$$F = \frac{1}{3} \pi^2 a^4 \left(b^2 - \frac{7}{5} bca + \frac{1}{2} c^2 a^2 \right) \quad (5)$$

The first part of this $\frac{1}{3} \pi^2 a^4 b^2$, is the force of attraction which would exist if the sphere were of uniform density b equal to the density at the centre in the case supposed. If M be the mass of the sphere in this case $M = \frac{4}{3} \pi a^3 b$, and

$$F = \frac{3}{16} k \frac{M^2}{a^2} \quad (6)$$

when the value k of the gravitation constant is inserted.

4. We shall now establish these results by the second method referred to above. In an examination paper set at Trinity College, Cambridge, in 1904, Mr. G. W. Walker gave the theorem that the attraction between two concentric thin hemispherical shells which have their circular edges in one plane and are turned in the same direction is equal to $\frac{1}{2}MM'/a^2$, where M, M' are the masses of the shells and a is the radius of the larger. This theorem was established by an application of zonal harmonics to the calculation of the attraction. The following intuitional proof¹ without analysis occurred to me a few days after Mr. Walker had told me the theorem in conversation :—

In the first place, the result evidently holds whether the shells standing with their edges in the same plane are turned in the same direction from that plane or not. For suppose a complete and uniform spherical shell to be constructed by adding an equal hemispherical shell A , say, to the outer of the two given shells, which we shall call B . This complete shell exerts no force on a particle anywhere within it, and therefore exerts none on the smaller shell (C say) now enclosed by it. The added shell A must therefore exert a force on C equal and opposite to that exerted by B on C . But the shells A and C have their circular edges in the same plane, and face in opposite directions from that plane. Therefore, the statement that no change in the attraction

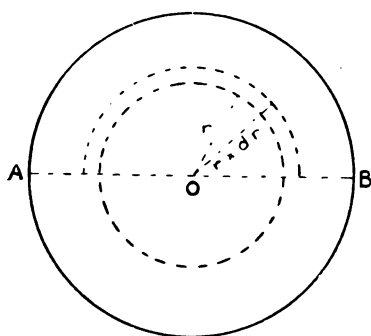


Fig 2

between the shells is produced by making them face in opposite directions is true.

If, then, before trying to find directly the attraction of B on C in the positions given, we suppose a hemispherical shell equal to C to be joined to it, so as to give a complete spherical shell instead of C , and of the same radius, we see by the result just obtained that the attraction exerted by

B on this spherical shell is just double that exerted by B on C . But the attraction of B on the complete shell is the same as if the whole mass of the latter were collected at its centre,

¹ See *Nature* for 14th April, 1904.

since this is the case for the attraction between the shell and every external particle. The attraction between the shell B of mass M and radius a and the smaller shell C of mass M' is therefore that between the shell B and a particle of mass M' at the common centre. A very simple integration proves this to be equal to the attraction between this latter particle and a particle mass $\frac{1}{2}M$ placed at the summit of B .

This theorem is capable of a certain amount of generalisation as I have shown in *Nature*, *loc. cit.*

5. To apply the theorem to the solution of the problem of the attraction between two halves of a sphere of density given by any function $f(r)$ of the distance from the centre, imagine both hemispheres divided into concentric hemispherical shells—each shell will attract every shell of the other hemisphere of radius x between o and r , as if its mass were collected at the centre; so that the attraction between the shell and the opposite hemisphere of the same radius is the same as if the whole mass of the latter were collected at the centre. This mass is

$$2\pi \int_0^r x^2 f(x) dx$$

and the attraction is by the theorem stated above

$$2\pi r^2 f(r) dr \int_0^r x^2 f(x) dx / r^2 = 2\pi^2 f(r) dr \int_0^r x^2 f(x) dx \quad (7)$$

The attraction between the shell of radius r and one of *larger* radius x in the other hemisphere is likewise

$$\frac{2\pi r^2 f(r) dr \cdot 2\pi x^2 f(x) dx}{2x^2} = 2\pi^2 r^2 f(r) dr f(x) dx ;$$

so that the total attraction between the shell of radius r and all the shells external to it in the other hemisphere is

$$2\pi r^2 f(r) dr \int_r^a f(x) dx \quad (8)$$

The whole attraction between the shell of radius r and the opposite hemisphere of radius a is the sum of the expressions in (7) and (8), that is

$$2\pi^2 f(r) dr \left\{ \int_0^r x^2 f(x) dx + r^2 \int_r^a f(x) dx \right\}$$

The whole attraction F between the hemispheres is therefore given by

$$F = 2\pi^2 \int_0^a f(r) dr \left\{ \int_0^r x^2 f(x) dx + r^2 \int_r^a f(x) dx \right\} \quad (9)$$

This gives the result for any law of symmetrical density.

In the case in which $f(x) = b - cx$,

$$\int_0^r x^2(b - cx) dx = \frac{1}{3}br^3 - \frac{1}{4}cr^4$$

and

$$\int_r^a f(x) dx = b(a - r) - \frac{1}{2}c(a^2 - r^2)$$

Thus the quantity in brackets in (9) is

$$-\frac{2}{3}br^3 + \frac{1}{4}cr^4 + bar^2 - \frac{1}{2}ca^2r^2$$

This multiplied by $2\pi^2(b - cr)$, and integrated from 0 to a , gives

$$F = \frac{1}{3}\pi^2 a^4 \left(b^2 - \frac{7}{5}bca + \frac{1}{2}c^2 a^2 \right)$$

which is equation (5) already obtained.

Equation (9) can be modified as follows. It is easy to see that

$$\int_0^a f(r) dr \int_r^a f(x) dx = \int_0^a f(r) dr \int_0^r x^2 f(x) dx \quad (10)$$

The two expressions really contain the same elements for integration, and the formal verification is easy by integration by parts. Thus (9) can be written in either of the forms

$$F = 4\pi^2 \int_0^a f(r) dr \int_0^r x^2 f(x) dx \quad (11)$$

or

$$F = 4\pi^2 \int_0^a f(r) r^2 dr \int_r^a f(x) dx$$

6. These equations can be obtained directly by the following considerations which really form the most direct and simple solution of the problem proposed. For the first form of the equation consider the attraction of the concentric sphere of radius r on a hemispherical shell of the same internal radius and thickness dr (see Fig. 2) standing on the plane of section AB .

The sphere acts as if its whole mass $4\pi \int_0^r x^2 f(x) dx$ were collected

at the centre, and its resultant attraction on the hemispherical shell is half the attraction which it would exert on a particle of mass equal to that of the shell, that is a mass $2\pi r^2 f(r) dr$, placed at the summit of the hemisphere. The attraction is therefore

$4\pi^2 f(r) dr \int_0^r x^2 f(x) dx$, so that

$$F = 4\pi^2 \int_0^a f(r) dr \int_0^r x^2 f(x) dx$$

since F is manifestly the sum of the forces which are exerted by all such spheres, of radii varying gradually from 0 up to a , in the series of coaxial hemispherical shells which fit the outer surfaces of the successive spheres, and make up the solid hemisphere the attraction on which is required.

The second form of the equation is obtained by considering the attraction of a complete concentric spherical shell, of radius r and thickness dr , on the whole series of thin shells, of which the part of the hemisphere, at a distance $x > r$ from the centre, may be regarded as composed. The attraction of the spherical shell just specified on a hemispherical shell of radius x is $4\pi r^2 f(r) dr \cdot 2\pi x^2 f(x) dx / 2x^2$, or $4\pi^2 r^2 f(r) dr f(x) dx$, and therefore its attraction on the external part of the hemisphere is $4\pi^2 r^2 f(r) \int_r^a f(x) dx$.

Hence summing up the actions of all such spherical shells on the parts of the hemisphere external to them we get the second equation in (11).

This process gives the attraction of the *whole sphere* on the hemisphere considered, but as the attraction of this hemisphere on itself is zero, the result is the force required.

These different forms of the integral and another which will be given later, though evident enough, are of some little interest, and may partly excuse what may seem a too elaborate discussion of an elementary problem.

7. It may be noticed that the method just explained is at once applicable to the

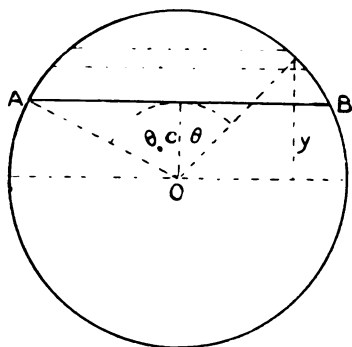


Fig 3

solution of the more general problem of finding the mutual attraction between any two segments into which a sphere is divided by a plane. For, consider the attraction of a sphere of radius r , on a segmental shell of the same radius (see Fig. 3). Let c ($< r$) be the distance of the plane of the edge of the shell from the parallel diametral plane of the sphere, and y the distance of a narrow parallel zone of the shell from the same plane. Let θ be the angle which a line drawn from the centre to the upper edge of the zone makes with the axis of the shell: then the breadth of the zone is $rd\theta$, and its radius $r \sin \theta$. The mass of the zone is therefore $2\pi r^2 f(r) \sin \theta d\theta dr$, and the mass of the sphere of radius r is $4\pi \int_0^r x^2 f(x) dx$. The resultant attraction between sphere and zone is along the axis of the latter and of amount

$$8\pi^2 f(r) \sin \theta \cos \theta \cdot d\theta dr \int_0^r x^2 f(x) dx$$

If θ_0 be the maximum value of θ , $\theta_0 = \sin^{-1}(\sqrt{r^2 - c^2}/r)$. Integrating with respect to θ from $\theta=0$ to $\theta=\theta_0$, we get for the attraction on the shell exerted by the internal sphere

$$4\pi^2 f(r) \sin^2 \theta_0 dr \int_0^r x^2 f(x) dx = 4\pi^2 f(r) \left(1 - \frac{c^2}{r^2}\right) dr \int_0^r x^2 f(x) dx$$

Hence the whole attraction F of the complete sphere on the segment of height $a - c$, is given by

$$F = 4\pi^2 \int_c^a f(r) \left(1 - \frac{c^2}{r^2}\right) dr \int_0^r x^2 f(x) dx \quad (12)$$

which can be calculated if $f(r)$ is known. This is the attraction on the segment of height $a - c$ exerted by the other segment, inasmuch as the attraction of the former (or either) segment on itself is zero. If c be zero we fall back on the particular case of (11).

As an example let $f(r) = b$, a constant. Then

$$\begin{aligned} F &= 4\pi^2 b^2 \int_c^a \left(1 - \frac{c^2}{r^2}\right) dr \int_0^r x^2 dx \\ &= \frac{1}{3} \pi^2 b^2 \int_c^a \frac{d}{dr} (r^2 - c^2)^2 dr \\ &= \frac{1}{3} \pi^2 b^2 (a^2 - c^2)^2 \end{aligned} \quad (13)$$

If $c\sqrt{2}=a$, so that $\theta_0=45^\circ$, the attraction is $\frac{1}{8}\pi^2b^2a^4$, that is in this case the attraction between the segments is half that between the hemispheres. If $c=0$, we get from (12) the result already established in (11).

8. The principle underlying the hydrostatic method used by Professor Tait is that of the imposition, or removal, of constraints on the system, when the process does not involve any alteration of the group of forces, the action of which it is desired to investigate, and is a principle frequently used in hydrostatics itself. It might probably be used with advantage to simplify some other problems which are found more or less troublesome. I shall give here a short account of the calculation, interpolating a special proof (§ 9) of the form of hydrostatic equation used, which, if the reader is acquainted with the equation, or chooses to assume it, may be omitted.

Let the sphere be conceived to be composed of a fluid held together by its own gravitation, which gives the law of density stated. Whether such a fluid can exist is not relevant to the discussion. Whatever the nature of the fluid the gravitational attraction necessitates at any point P , at distance r from the centre, a gradient of pressure variation in the direction along the radius, which can be found from the conditions imposed. From the pressure gradient the pressure at any point can be calculated. This pressure from the condition of fluidity is the same in all directions at the point, and therefore we are able to find from its value for each point the total thrust due to pressure over a diametral plane. This must be the force with which one hemisphere is attracted by the other. This attractive force on either hemisphere has a value independent of the hypothesis of fluidity, and is balanced by the pressure-thrust exerted upon it across the diametral plane by the other hemisphere. The equation for the gradient is known from hydrostatic principles to be

$$\frac{dp}{dr} + f(r)R = 0 \quad (14)$$

if $f(r)$ denote the density of the fluid.

9. Consider a narrow cone drawn from the centre as vertex so as to contain the point P , and let ds_1, ds_2 be the areas intercepted by this cone on two spherical surfaces concentric with the sphere, one internal the other external to P , at a small distance dr apart, and at equal distances $\frac{1}{2}dr$ from P . If p be the pressure at the

inner surface the outward thrust or pressure-force exerted on ds_1 by the fluid internal to the inner surface is $p ds_1$. If dp/dr be the rate of increase of pressure per unit of distance outwards at P , the pressure at the outer surface is $p + dp/dr \cdot dr$ and the inward thrust exerted on ds_2 by the external fluid is $(p + dp/dr \cdot dr) ds_2$. Hence, on the whole, pressure on the surfaces ds_1 , ds_2 , gives an inward force on the fluid contained in the part of the cone between ds_1 and ds_2 , of amount $(p + dp/dr \cdot dr) ds_2 - p ds_1$. If $d\omega$ denote the solid angle of the cone (that is the area intercepted by the cone on the sphere of unit radius drawn from the vertex as centre),

$$ds_1 = \left(r - \frac{1}{2}dr\right)^2 d\omega, \quad ds_2 = \left(r + \frac{1}{2}dr\right)^2 d\omega$$

or since dr is small in comparison with r

$$ds_1 = (r^2 - r dr) d\omega, \quad ds_2 = (r^2 + r dr) d\omega$$

The force just found may therefore be expressed in the form

$$\left\{ \left(p + \frac{dp}{dr} \right) (r^2 + r dr) - p (r^2 - r dr) \right\} d\omega,$$

or when higher powers of dr than the first are neglected

$$\left(\frac{dp}{dr} + \frac{2}{r}p \right) r^2 dr d\omega.$$

Besides this force applied at the surfaces ds_1 , ds_2 , an outward force is exerted in consequence of the pressure on the inward tapering lateral surface of the portion of the fluid considered. Let

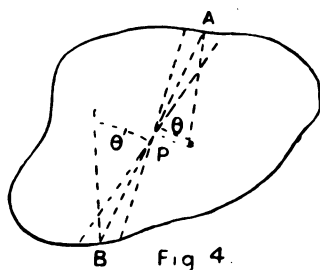


Fig. 4.

the closed curve in Fig. 4 represent the periphery of a cross-section of the narrow cone through P , midway between ds_1 and ds_2 , and the two lines shown drawn through P represent the intersections of two planes through the centre and through P . These lines intercept on the periphery of the cross-section, at

A and B as shown in Fig. 4, lengths ds , ds' . The inward drawn normals to ds , ds' , drawn in the plane of the cross-section, are inclined at angles θ , θ' to the line through P bisecting ds and ds' . The thrust on the part of the lateral surface at the portion of the cone between the two planes and the two cross-sections and containing ds , is $p ds dr$. The component of this force in the

direction of OP , the line from the centre to P , is $pdrds \cos \theta.AP/r$. Similarly, on the other part of the surface containing ds' the force is $pdrds' \cos \theta'.BP/r$. Adding these two results we get for the outward force due to the pressure on these portions of the lateral surface of the cone

$$p \frac{dr}{r} (AP.ds \cos \theta + BP.ds' \cos \theta').$$

But the expression in brackets is twice the area between the two lines through P in Fig 4. By drawing planes as described, so as to contain the line OP , we can exhaust the whole area enclosed by the curve in Fig. 4, and get for the total outward force, since twice this whole area is $2r^2 d\omega$, the value

$$2prdrd\omega$$

The total inward force due to pressure is thus

$$\left(\frac{dp}{dr} + \frac{2p}{r} \right) r^2 dr d\omega - 2prdrd\omega = \frac{dp}{dr} r^2 dr d\omega.$$

But if R be the force on unit mass at P due to the gravitation of the sphere, the force on the mass between ds_1 and ds_2 , that is the mass $f(r)r^2 dr d\omega$, is $f(r)r^2 R dr d\omega$. But since this mass is in equilibrium the whole force upon it must be zero. Hence as this total inward force is $\{dp/dr + f(r).R\} r^2 dr d\omega$ we must have

$$\frac{dp}{dr} + f(r).R = 0 \quad (14)$$

the equation stated above for the gradient of pressure.

10. From (14) by integration we obtain p . In fact if p_0 be the value of the pressure for $r=0$, and p_r that for any distance $r(<a)$ from the centre,

$$p_r = - \int_0^r f(x).R_x dx + p_0 \quad (15)$$

where x is put for the varying value of r under the sign of integration. But since for any distance y from the centre, the density is $f(y)$, and the mass of a shell of radius y and thickness dy is $4\pi y^2 f(y) dy$, the whole mass of the sphere of radius x is $4\pi \int_0^x y^2 f(y) dy$, and therefore

$$R_x = \frac{4\pi}{x^2} \int_0^x y^2 f(y) dy$$

and (15) becomes

$$p_r = - 4\pi \int_0^r \frac{f(x)}{x^2} dx \int_0^x y^2 f(y) dy + p_0 \quad (16)$$

But when $r=a$, $p_r=p_a=0$, so that (16) then gives a value of p_o . This value substituted in (16) gives

$$p_r = 4\pi \int_r^a \frac{f(x)}{x^2} dx \int_0^x y^2 f(y) dy \quad (17)$$

The thrust of one hemisphere against the other, and therefore the total gravitational attraction between them, is got by taking the surface integral of p_r over a diametral plane. Thus

$$F = 8\pi^2 \int_0^a r dr \int_r^a \frac{f(x)}{x^2} dx \int_0^x y^2 f(y) dy \quad (18)$$

11. It is easy to show that this integral is equivalent to either of those already given in (11). For putting

$$\phi(a) - \phi(r) = \int_r^a \frac{f(x)}{x^2} dx \int_0^x y^2 f(y) dy$$

we have

$$F = \int_0^a \{ \phi(a) - \phi(r) \} r dr$$

Integrated by parts this gives

$$\begin{aligned} F &= \frac{a^2}{2} \{ \phi(a) - \phi(a) \} + \frac{1}{2} \int_0^a r^2 \phi'(r) dr \\ &= \frac{1}{2} \int_0^a x^2 \phi'(x) dx \end{aligned}$$

But

$$\phi'(x) = \frac{f(x)}{x^2} \int_0^x y^2 f(y) dy$$

and therefore

$$F = 4\pi^2 \int_0^a (x) dx \int_0^x y^2 f(y) dy$$

which is one of the forms in (11).

As remarked above, a similar method may be used for the identification of the two forms of (11).

This hydrostatic method may be used also to calculate the mutual attraction between two unequal segments; but in view of the discussion above this application is left to the reader.

12. Returning now to the case of $f(r) = b - cr$, we have from (10) as in (5)

$$F = \frac{1}{3} \pi^2 a^4 (b^2 - \frac{7}{8} bca + \frac{1}{2} c^2 a^2) \quad (19)$$

The first term in this, $\frac{1}{3} \pi^2 a^4 b^2$, is the attraction which would exist if the sphere had throughout the density at the centre; the second

and third terms give the effect of the variation of the density with distance from the centre. It will be observed that this effect is an increase or a diminution, from the value for uniform density equal to the maximum b , according as c is greater or less than $14b/5a$. If c were negative, so that the density diminished towards the centre, this effect would always be an increase of attraction.

In the case of the earth the mean density and the surface density may be taken at 5.5 and 2.7 respectively. Hence assuming for the earth the law of density stated, we have

$$\text{and therefore } \left. \begin{aligned} b - \frac{3}{4}ca &= 5.5, \quad b - ca = 2.7 \\ b &= 13.9, \quad ca = 11.2 \end{aligned} \right\} \quad (20)$$

Thus $c = 11.2/a$, which is much less than $38.92/a$, the value of $14b/5a$. The attraction is, therefore, much less than it would be if the central density b held throughout. The ratio of the diminution to the value that would then hold for the attraction is $(\frac{7}{8}bca - \frac{1}{8}c^2a^2)/b^2$, or about $\frac{4}{5}$, according to the values of b and ca just stated. The attraction between the hemispheres is thus only about $\frac{1}{5}$ of what it would be if the central density held throughout.

When the mean density $\rho_m = b - \frac{3}{4}ca$ is used (5) or (19) becomes

$$F = \frac{1}{3}\pi^2 a^4 (\rho_m^2 + \frac{1}{10}\rho_m ca + \frac{1}{80}c^2 a^2) \quad (21)$$

Hence if c be positive, that is if the density decrease from the centre outwards, the force is greater than if the density were uniform and equal to the mean density. [If c were negative, let us say equal to $-c'$, then the force would be greater or less than that for mean density according as $c'a > \text{or} < 8\rho_m$.] The ratio of the increase to the value of the force for uniform density is $(\frac{1}{10}\rho_m ca + \frac{1}{80}c^2 a^2)/\rho_m^2$, or about $\frac{1}{4}$. The attraction is therefore greater than it would be if the density throughout were the average density, by about 25 per cent. of the value which it would have in that case.

13. To compare these results with the strength of materials we may take a specimen of steel for which the breaking stress has been found to be 28 tons per square inch, or about 4.55×10^9 dynes per square centimetre. This is the force required to pull apart two hemispheres of a steel ball of diametral section one square centimetre, and of this, gravitational attraction calculated on the hypothesis of uniform density, can supply only an infinitesimal

fraction. But as shown by (5), (19), or (21), the gravitational strength, as we may call it, increases rapidly with the radius. The radius a of a sphere of steel, the gravitational strength of which is equal to the breaking stress just quoted, multiplied by the area of a diametral plane is given by the equation

$$\frac{1}{3}k\pi^2a^4\rho^2 = 4.55 \times 10^9 \times \pi a^2$$

where k is the gravitation constant [see p. 212 below : which, for c.g.s. units, has the value 6.7×10^{-8}] a is taken in centimetres and ρ , the density, is 7.8. Thus we have

$$a^2 = \frac{3 \times 4.55 \times 10^{17}}{\pi \times 7.8^2 \times 6.7} = 10.64 \times 10^{14}$$

Hence $a = 3.26 \times 10^7$, in centimetres, nearly. Thus a sphere of steel 326 kilometres in radius, or about 400 miles in diameter, would have a gravitational strength equal to that calculated from the breaking stress of steel. The strength of the earth due to its gravitational attraction is, of course, enormously greater than anything that could be due to the cohesion of the matter of which it is composed, even if that were as strong to resist traction as the best steel.

The question of the cause of cohesion has been discussed by various writers, but it can only be pointed out here that it can have its origin only in the molecular structure of matter. If the ultimate molecules of any material consist of particles of great mass each in small space, and therefore individually of great density, though yielding in the aggregate only a moderate average density, a comparatively small number of these brought into near proximity might, even according to the ordinary law of gravitation, give a considerable cohesive force. This would manifest itself as a deviation from the gravitational strength found on the supposition of uniform density throughout the whole volume occupied (if not filled) by the body. It has been found necessary, in order to explain properties of matter, to call in attractions and repulsions varying according to different laws of distance of the particles (or centres of force as they have been imagined to be on the hypothesis of Bosovich) ; but in our ignorance of the motions of the particles, which must profoundly affect the result, all such discussions are more or less futile.

14. Finally may be mentioned a method of finding the attraction between two segments of a body separated by a plane interface,

which is applicable when the body is of uniform density (or at least of density uniform in each of the planes over which the integration specified below is taken), and when the field of gravitational force due to the body is fully known. It was proved by Gauss that if a closed surface be described in any field of gravitational (or electric or magnetic) force, the surface integral of normal force¹ (that is normal component of field-intensity) taken over the closed surface, is equal to 4π times (or to $4\pi k$ times, if the constant k of gravitation is introduced) the matter contained within the surface. It is very remarkable that this integral should depend on the quantity of matter *within* the surface, and not all on the matter without the surface, though the latter, of course, affects the value of the force at each point of the surface.

15. We shall apply the method first to a sphere of uniform density. Let, as supposed above, the sphere be of radius a , and the plane of section AB be at a distance c from a parallel diametral plane (see Fig. 5). Imagine a closed surface described, coinciding with the surface of the sphere except where it cuts through the sphere in a plane parallel to the plane of section, as shown in Figure 5 by the dotted line and curve. The normal force which would be exerted on a particle of unit mass at any point of the

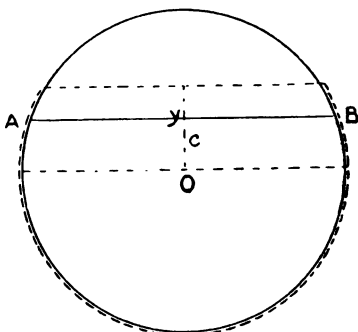


FIG 5

curved portion of the surface is (in the units obtained by taking $k=1$) M/a^2 where M is the mass of the whole sphere. The area of the curved part of the surface, if we suppose it to surround the greater segment, and to extend to a distance $y > c$, from the diametral plane mentioned above, is $2\pi a(a+y)$. The surface integral of normal force over this part is therefore $2\pi a(a+y)M/a^2$ or $\frac{8}{3}\pi^2 pa^2(a+y)$. If the unknown portion of the surface integral over the plane part of the closed surface be denoted by I , the whole surface integral is $\frac{8}{3}\pi^2 pa^2(a+y) + I$.

¹ It is to be observed that "force" here, and frequently elsewhere, signifies the force which would be exerted on *unit of mass* concentrated at the point considered. It measures what is known as the field-intensity at the point.

The matter contained within the closed surface is $\frac{1}{3}\pi\rho(2a^3 + 3a^2y - y^3)$. Hence the equation.

$$\frac{8}{3}\pi^2\rho a^2(a+y) + I = \frac{4}{3}\pi^2\rho(2a^3 + 3a^2y - y^3)$$

which gives

$$I = \frac{4}{3}\pi^2\rho(a^2 - y^2)y \quad (22)$$

Now, consider a disk of thickness dy one face of which is the plane for which I has been found. The mass of the disk is ρdy per unit area, and as I is the surface integral of the normal field-intensity, the pull on the disk is $I\rho dy$, or $\frac{4}{3}\pi^2\rho^2(a^2 - y^2)y dy$. This is due to the whole mass in the field. The whole pull on the segment of height $a - c$ and density ρ is therefore

$$F = \frac{4}{3}\pi^2\rho^2 \int_c^a (a^2 - y^2)y dy$$

or

$$F = \frac{1}{3}\pi^2\rho^2(a^2 - c^2)^2 \quad (23)$$

which agrees with (12) above.

16. This method may be applied in other cases, for example, to find the mutual force per unit length between the longitudinal segments of a right circular cylinder of uniform density and infinite length, made by a plane parallel to the axis. The closed surface consists in this case of a cylindrical portion and a plane part round one segment considered and two ends coinciding with the terminal cross-sections of the portion of cylinder considered. The work is left to the reader, with the note that the external field of force due to the cylinder is the same as that due to a straight filament of mass equal to the mass of the cylinder and coinciding with the axis of symmetry.

In the general case we have

$$\int_s N ds + I = 4\pi M$$

where N is the normal force at an element ds of the portion of the surface other than the plane over which I is taken, and the integral is taken for all such elements. Hence

$$I = 4\pi M - \int_s N ds$$

Thus

$$F = \int I \rho dy = \int (4\pi M - \int_s N ds) \rho dy \quad (24)$$

where the integration with respect to y is taken for all values of y (the distance of the plane of I from the diametral plane within the segment for which the attraction is required. The value of ρ need not be uniform within the segment, but only over each plane parallel to that of section. In such a case, however, the calculation of N would present difficulties.

II. *The Attraction of Ellipsoidal Shells and of Solid Ellipsoids at External and Internal Points, with some Historical Notes.*

1. I wrote out the greater part of the following paper while on a holiday this summer, and was not aware until my return home that the method given below (§§ 24, 28 to 30) for the determination of the potential of a homothetic ellipsoidal shell had been anticipated by a passage in Thomson and Tait's *Natural Philosophy* (Part ii., § 525). That also, I have since found, had been anticipated in § 24 of the beautiful memoir by Chasles, "Sur l'attraction d'une couche ellipsoïdale," in the *Journal de l'Ecole Polytechnique* (t. xv., 1835). The investigation contained in §§ 14 to 18 below is, however, quite distinct, and I think new. It gives a complete solution of the problem of the shell and the ellipsoid, and leads naturally to the other discussion already referred to, which differs in some respects from the solution of Chasles. I have, moreover, worked out in detail some particular problems. With all due acknowledgment, therefore, I venture to allow my notes to stand.

2. No problem in the Theory of Attractions has received more attention than that of the attraction of a solid ellipsoid on an external particle. The subject engaged the attention of Newton and Maclaurin,¹ who dealt with it by a combination of the geometrical methods of which these mathematicians had such a perfect mastery, and the results of Newton's own calculus of fluxions and fluents (differential and integral calculus); and all the celebrated analysts of the end of the eighteenth century and the beginning of the nineteenth, Laplace, Lagrange, Ivory, Gauss,

¹See Newton's *Principia*, Lib. I., ss. xii. and xiii., and Maclaurin's *Treatise on Fluxions*, Vol. II.

Poisson, Chasles, wrote memoirs on the subject which have become classical. To find the attraction of the ellipsoid at an internal point had been soon found to be a comparatively easy matter. The process adopted was to take the attracted point as origin of polar co-ordinates by which the positions of the particles of the ellipsoid (supposed of uniform density) were specified, to express the volume of the attracting body by these co-ordinates, and then the components of attraction on the particle as triple integrals with respect to the radius-vector and the two angular co-ordinates. As Poisson puts it in the introduction to the very remarkable memoir¹ read to the Académie des Sciences on October 3, 1833 :—"The integration with reference to the radius-vector can be carried out without any difficulty, and in the case of an internal point a second integration is easily effected, so that the three components of attraction are expressed by single integrals, reducible to elliptic integrals of the first and second kinds. These integrals are obtainable in a finite form when the ellipsoid is one of revolution. When, however, the attracted particle lies outside the ellipsoid, the double integrals contain a radical, and have limits which render them much more complicated, so that, instead of carrying out the second integration directly, we have to turn the difficulty by reducing the problem for the external point to that for an internal point, which leaves the problem of the direct integration unsolved. For this reduction the theorem of Ivory leaves nothing to be desired."

3. Ivory's theorem depends on his notion of corresponding points on two ellipsoidal surfaces, the axes of which are coincident. Let a, b, c be the lengths of the semi-axes of one, say the smaller, ellipsoid, x, y, z the co-ordinates of a point P on the surface, and similarly a', b', c', x', y', z' the lengths of the semi-axes of the larger ellipsoid, and the co-ordinates of a point Q upon it. If the co-ordinates fulfil the relations $x/a = x'/a', y/b = y'/b', z/c = z'/c'$, the points P, Q are corresponding points. It is easy to show that if P, P' be two points on the first ellipsoid, Q, Q' the corresponding points on the other, and the ellipsoids be confocal, the distances $PQ, P'Q$ are equal.

Now considering attractions in the directions of the principal axes, and taking first the axes a, a' , it can be proved that the attraction X of the first ellipsoid, A say, on a particle of unit mass

¹ Mémoires de l'Académie Royale des Sciences de l'Institut, t. xiii., 1835.
VOL. XXXVII. O

at Q on the surface of the other ellipsoid, B , is to the attraction X' of the ellipsoid B on a unit particle at the corresponding point P on the surface of A , in the ratio $bc/b'c'$. Similarly $Y/Y' = ca/c'a'$, $Z/Z' = ab/a'b'$. The ellipsoids are here supposed to be solid and of uniform density, ρ say, and confocal. If we call the masses of the ellipsoids M, M' then since $M/M' = abc/a'b'c'$, we may express the theorem in the form (not given by Ivory)

$$\frac{X}{X'} = \frac{a'}{a} \frac{M}{M'}, \quad \frac{Y}{Y'} = \frac{b'}{b} \frac{M}{M'}, \quad \frac{Z}{Z'} = \frac{c'}{c} \frac{M}{M'}. \quad (1)$$

When expressed in this form the theorem is evidently true whether the two ellipsoids have the same density or not, provided that each is homogeneous. For the components of force on a unit particle evidently vary with the masses of the ellipsoids, when their dimensions remain unchanged, and therefore change in the ratio M/M' , caused by varying the density of either ellipsoid, is represented by a corresponding change in each of the ratios $X/X', Y/Y', Z/Z'$.

In the particular case of $M = M'$, the theorem takes the form

$$\frac{X}{X'} = \frac{a'}{a}, \quad \frac{Y}{Y'} = \frac{b'}{b}, \quad \frac{Z}{Z'} = \frac{c'}{c}. \quad (2)$$

It was first pointed out by Poisson that Ivory's theorem is true for every law of attraction, provided the law is a function of the distance only.

4. Let us now suppose that the problem of finding the attraction of a homogeneous ellipsoid at an internal point has been solved, and that it is required to find the attraction at an external point, Q say. It is only necessary to find for the corresponding point P on the surface of the given ellipsoid the attraction exerted on a unit particle by the confocal ellipsoid, the surface of which contains the point Q . The components are given by (1), and thus the so-called external problem is reduced to the internal problem of which the solution is known.

5. The external problem was, however, solved directly by Poisson in the memoir above referred to, by the device, which he appears to have been the first to adopt, of imagining the ellipsoid divided into infinitely thin similar and similarly situated ellipsoidal shells, or "elliptic homœoids" as they have been called by

Thomson and Tait,¹ then finding by direct integration the attraction exerted by such a shell on a unit particle at the given external point, and finally passing, by another integration from shell to shell, to the attraction exerted by the solid ellipsoid.

[The term homothetic ellipsoidal shell is used by many writers for the "couche elliptique" on which Poisson based his solution, and is perhaps less open than the term elliptic homœoid to objection on the ground of derivation; but we shall adopt the name elliptic homœoid, or simply homœoid, where there is no risk of ambiguity. Thomson and Tait also give the name "focaloid" to a shell bounded by two confocal ellipsoidal surfaces.]

6. On Ivory's notion of corresponding points Chasles based a very important and elegant theorem of the attraction of confocal homœoids. Imagine two elliptic homœoids, A, B , of infinitesimal thickness, and each of uniform (not necessarily the same) density, the two outer surfaces and the two inner surfaces of which are confocal. Let a, b, c be the lengths of the semi-axes of A , and a', b', c' the same quantities for B . Also let P and Q be corresponding points on the two shells. The theorem of Chasles affirms that the potential at the point Q due to the homœoid A is to the potential at P due to the homœoid B , as the mass of A is to the mass of B .

For let ds be an element of A and ds' the corresponding element of B , and p, p' the lengths of the perpendiculars from the centre on the tangent plane at the elements. It is easy to prove that

$$\frac{p' ds'}{p ds} = \frac{a' b' c'}{abc} \quad (3)$$

The masses of corresponding elements of the shell are $\beta p ds$, $\beta' p' ds'$, where β, β' are constants depending on the density and scale of thickness in the two cases. The total masses are βabc , $\beta' a' b' c'$ respectively. Hence it follows that the masses of corresponding elements are in the ratio of the total masses in the two cases. [See § 13 below for the value of β, β' .]

Now, if r be the distance of Q from any element of the shell A , it is also the distance of P from the corresponding element of B . If β, β' be constant multipliers, as already explained, the

¹ Nat. Phil., Part II., § 494 g.

potential at Q due to the matter at ds is $\beta p ds/r$, and the potential at P due to the matter at ds' is $\beta' p' ds'/r$.¹ The former bears to the latter the ratio $\beta abc/\beta' a' b' c'$. Since this is true of every element the total potentials have the ratio just stated, that is the ratio of the masses of the shells.

It follows from this theorem that if the potential at an internal point is known for a thin elliptic homœoid, the potential at an external point can be found, and *vice versa*, by considering a confocal shell.

7. These results are true whatever the law of attraction may be, if only it is a function of the distance, as may be seen by substituting $f(r)$ for $1/r$ in the expression for the potential of an element. In the case of ordinary matter the law of attraction is that of the inverse square of the distance, and the potential determined is commonly called the Newtonian potential.

It is well known (and it will be referred to again presently) that the Newtonian potential of a homœoid is the same at every internal point, and therefore also at every point of the shell, since the potential is not discontinuous at points within attracting matter of finite volume density, or even at passage across a surface of finite surface density. Thus in order to find the potential at an external point P , due to a given elliptic homœoid, it is only necessary to imagine a confocal homœoid of equal mass constructed so as to have P on its surface, and find the uniform potential which it produces at every internal point. This is the potential required.

8. It follows from the result that the external confocal ellipsoidal surfaces are the equipotential surfaces of a uniform homœoid, and that such a shell is itself at uniform potential. The resultant attraction due to such a shell exerted on a particle at an external

¹ We take here as the specification of the potential

$$V = \sum \frac{dm}{r}$$

where r is the distance of the point for which the potential is defined from an element dm of the attracting matter, and Σ denotes summation for all elements. Here the unit of mass is that which concentrated at a point at unit distance from an equal mass, also concentrated at a point, is attracted with unit force. When the ordinary unit of mass, the gramme, say, is used, the right hand side of the equation for V must be multiplied by the value of the force of attraction which exists between two such units of mass placed at unit distance, a centimetre, say, apart. This multiplier is called the "gravitation constant." It is generally omitted (that is taken as unity) in what follows: where it is inserted it is denoted by κ .

point is along the normal through the point to the confocal surface on which the point lies.

It can be seen at once without analysis that an elliptic homœoid exerts no force at any point in the internal hollow, that is, that the potential has there a uniform value. For the shell may be imagined constructed by homogeneously straining a uniform thin spherical shell, within which, of course, the potential is uniform. Such strain is that which elongates all parallel dimensions of the shell in the same ratio, and therefore leaves it of uniform density, though of varying thickness, proportional to the length of the perpendicular from the centre on the tangent plane at each point. If then a cone of small solid angle be drawn with its vertex at any point in the hollow of the spherical shell, so as to intercept two elements of the surface, these two elements exert equal and opposite forces on a particle at the vertex. By the strain the masses of these two elements are not altered, nor the ratio of their distances from the vertex of the new cone into which the former one is changed. The elements, therefore, still exert equal and opposite forces on a particle at the vertex. Hence, as cones can be thus drawn so as to exhaust the shell by pairs of elements, the shell as a whole exerts no force at the common vertex.

9. The same idea of division of a solid ellipsoid into homœoids had, however, occurred to O. Roderigues, and been used by him in a "*Mémoire sur l'attraction des Sphéroïdes*," published in the *Correspondance sur l'Ecole Polytechnique* (t. iii., 1816). The method adopted for the solution of the problem of the attraction of a solid ellipsoid seems to have been suggested by a previous paper by Gauss, and consists in finding the variation, δW , say, in the ratio of the potential of the ellipsoid at the given point, h, k, l , say, to the mass of the solid, when the squares of the semi-axes a^2, b^2, c^2 are all altered by the same small amount, $\delta\phi$, say, that is by the passage from the given ellipsoid to an adjacent confocal ellipsoid. It is shown that for an external point $\delta W = 0$, and for an internal point

$$\delta W = \frac{3}{4} \frac{\delta\phi}{abc} \left(\frac{h^2}{a^2} + \frac{k^2}{b^2} + \frac{l^2}{c^2} - 1 \right) \quad (4)$$

From these results Roderigues deduced the attraction of the ellipsoid at the given point. It is easy to find from them an expression for the potential. (See § 18 below.)

The determination of δW depends on the evaluation of a

certain integral taken throughout the volume of the ellipsoid in which the element of volume is expressed in ordinary polar co-ordinates. The integral is transformed by considering a homothetic shell within the ellipsoid, and taking as the element of volume that intercepted between the two surfaces at an element ds of one of them. Then the integration is effected for the whole shell to which ds belongs, and then carried from shell to shell for the whole ellipsoid.

It is to be noticed that Roderigues did not determine the attraction or the potential due to a single homothetic shell, but merely imagined the solid ellipsoid divided into such shells in his process of integration.

10. In the volume of the "*Mémoires de l'Institut*" (t. xv., 1835) already referred to and immediately preceding the memoir cited, is a "*Mémoire sur l'attraction des Ellipsoïdes*," also by Chasles, in which the mode of division into homothetic shells is used, and is attributed to Poisson. There can be no doubt that Poisson was the first to calculate explicitly the attraction of such a shell at an external point, and to apply it to the problem of the solid ellipsoid; but it is equally clear that the idea of this mode of division is of earlier date. Over this point arose in 1837 a curious reclamation. Another memoir by Chasles, in which the same method was used, was referred by the Académie des Sciences to Libri and Poincot. The latter reported without mentioning Poisson's memoir of 1835, and thereupon Poisson in the "*Comptes Rendus*" (t. vi., pp. 837-840) called attention to this mode of decomposition of a solid ellipsoid, and affirmed that it afforded the only means of reducing the double integrals of the problem to single integrals. Poincot rejoined re-affirming the priority of Roderigues in this matter, and the discussion was closed by some further remarks by Poisson, and a second rejoinder from Poincot. These are to be found at the beginning of the next volume of the "*Comptes Rendus*": a fairly full account of the controversy is given also by Todhunter in his "*History*."

11. In Poisson's memoir of 1835 it is proved that the resultant attraction of an elliptic homœoid at an external point f, g, h , is directed along the internal axis of the cone drawn from the external point as vertex to touch the homœoid. This is a very remarkable theorem, and attracted very considerable attention. For that axis of the cone is the normal to the confocal ellipsoidal surface through f, g, h ; and the theorem at once gives the family

of external confocal ellipsoidal surfaces as the equipotential surfaces of the homœoid. The importance of these surfaces was not perceived until later, when the researches of Green, Gauss, Chasles, and others had become known, and had led to new methods of treating problems of attraction—methods which had become essential for the progress of the theory of electricity.

Poisson resolved the force due to each element of the homœoid along the axis of the cone, and by expressing the component in terms of polar co-ordinates referred to f, g, h as origin, was able to obtain the resultant force in an integrable form. His process is one of direct integration of the expressions obtained, and involves some troublesome considerations as to the limits of the integration with respect to θ , the angle between the axis of the cone and the line drawn to the element considered, and therefore runs to considerable length.

12. A very different process of calculating this integral is followed by Chasles in his memoir already cited, "*Sur l'attraction d'une couche ellipsoïdale.*" There the theorem of Lamé (given for the steady motion of heat in a uniform solid), that Laplace's differential equation of the potential is integrable when the equipotential surfaces are known, is employed for the family of equipotential surfaces revealed by Poisson's theorem, and the attraction is reduced to the evaluation of a constant left undetermined by the integration of the specialised form of the differential equation for this case. This is effected by considering the particular case of the attracted point on the surface, evaluating the integral for this case, and comparing with the expression obtained from the integration of the differential equation.

13. I shall now show how the integral for the resultant force at f, g, h , expressed in terms of the element ds , its co-ordinates x, y, z , the perpendicular p from the centre on the tangent plane at ds , the distance r from the point f, g, h to ds , and the angle θ between this line and the axis of the cone, can, by means of a simple geometrical theorem of confocal surfaces, which I have not before seen remarked, be transformed to an immediately integrable form, so that the whole calculation can be set forth very briefly.

In order that the result may be at once applicable to the calculation of the potential of a solid ellipsoid, I take as the equation of the outer surface

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} + \frac{z^2}{c^2} = k$$

or in the usual abridged notation

$$\Sigma \frac{x^2}{a^2} = k \quad (5)$$

where k is less than 1. The equation of the inner surface is

$$\Sigma \frac{x^2}{a^2} = k - dk \quad (6)$$

as k must diminish from the value unity, for the surface of the equation

$$\Sigma \frac{x^2}{a^2} = 1,$$

to zero when the axes are of infinitesimal length. Further, I shall take as the equation of the confocal surface

$$\Sigma \frac{x^2}{a^2 + u} = k \quad (7)$$

The thickness of the homœoid at the point A , of co-ordinates x, y, z , on its outer surface is $\frac{1}{2}pdk/k$, and the mass of an element of area ds at the same point of the shell is $\frac{1}{2}p\rho dsdk/k$, where p is the length of the perpendicular from the centre on the tangent plane at x, y, z , and ρ is the volume density of the matter of the shell. For the thickness of the shell is clearly $\Sigma(xdx/a^2)/\sqrt{\Sigma(x^2/a^4)}$, that is $p\Sigma(xdx/a^2)/k$, and by differentiation of (5) this is at once seen to be $\frac{1}{2}pdk/k$. Thus $\frac{1}{2}p\rho dk/k$ is the constant β of § 6 above.

14. I shall now establish the geometrical lemma referred to in § 13 above, on which will be based a proof of Poisson's theorem that the resultant force exerted by the homœoid on a unit particle at the external point P of co-ordinates f, g, h acts along the normal to the confocal through P : then I shall give a very simple and direct calculation of the amount of this resultant force, and finally obtain the potential of the homœoid, and of a solid ellipsoid, at any external point.

Let the enveloping cone be drawn from P as vertex to the external surface (5) of the homœoid. The points of contact lie in the polar plane of P ; and the internal axis of the cone, the normal at P to the confocal, meets this plane in a point Q . Now let a line drawn from P at any angle θ_0 to PQ meet the homœoid in the two points A, B (see Fig. 6.) Consider for the present only one of these, A , and let x, y, z be its co-ordinates, and r denote its distance from P . P is on the confocal represented by (7): let

P_1 (co-ordinates f_1, g_1, h_1) be the corresponding point on the surface (5) of the homœoid, and A' (co-ordinates x', y', z') be the point on the confocal corresponding to A . The distance of A' from P_1 is also r by the property of pairs of corresponding points. Also $f_1, g_1, h_1 = fa/a', gb/b', hc/c'$ and $x', y', z' = xa'/a, yb'/b, zc'/c$, where $a', b', c' = \sqrt{a^2 + u}, \sqrt{b^2 + u}, \sqrt{c^2 + u}$.

Now let p_o, p' , be the lengths of the perpendiculars from the centre on the tangent plane at P , and the tangent plane at A'

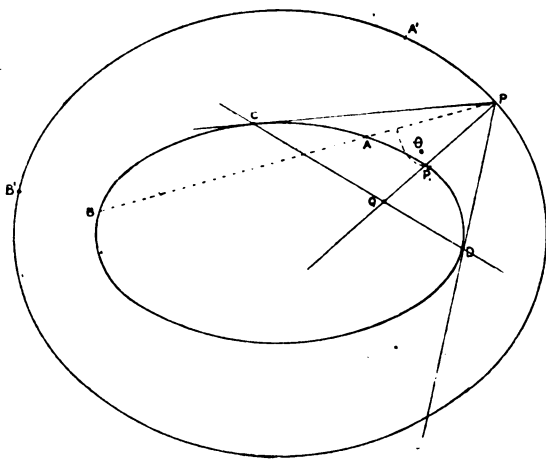


Fig. 6.

respectively, and θ denote the angle between the latter perpendicular drawn outwards and the line $P_1 A'$. The lemma to be established is expressed by the equation.

$$p' \cos \theta_o = p_o \cos \theta$$

In order to express $\cos \theta_o$ we have the direction cosines of QP and AP . These are $\{f/(a^2 + u), g/(b^2 + u), h/(c^2 + u)\} p_o/k$ and $(f - x, g - y, h - z)/r$. Hence

$$\cos \theta_o = \frac{p_o}{k} \sum \left(\frac{f - x}{r} \frac{f}{a^2 + u} \right) = \frac{p_o}{rk} \left(k - \sum \frac{fx}{a^2 + u} \right) \quad (8)$$

or as we may write it

$$\cos \theta_o = \frac{p_o}{rk} \left(k - \sum \frac{f_1 x'}{a^2 + u} \right) \quad (8')$$

Similarly we obtain

$$\cos \theta' = \frac{p'}{rk} \left(k - \sum \frac{f_1 x'}{a^2 + u} \right) \quad (9)$$

so that

$$p' \cos \theta_0 = p_0 \cos \theta'. \quad (10)$$

which was to be proved. A similar relation of course holds also for the points P_1 , A on the homœoid.

This theorem, it is to be remarked, is not confined to confocal ellipsoidal surfaces.

15. Now, imagine drawn from P as vertex a cone of small solid angle $d\omega$. It will intercept two elements of the homœoid: let ds be the area of that at A . The length of the perpendicular from the centre on the tangent plane at A being p , the mass of the element is $\frac{1}{2} \rho p dk ds / k$; and if ds' be the element of the surface of the confocal corresponding to ds , that is, containing the points corresponding to those contained in ds , we know that

$$p ds = \frac{a b c}{\sqrt{(a^2 + u)(b^2 + u)(c^2 + u)}} p' ds'. \quad (11)$$

The attraction at right angles to the axis PQ exerted by the element on a unit particle at P is when $\kappa = 1$ (see footnote § 6)

$$\frac{1}{2} \rho \frac{dk}{k} \frac{p ds}{r^2} \sin \theta_0$$

which by (11) and (10) may be written

$$\frac{1}{2} \rho p_0 \frac{dk}{k} \frac{a b c}{\sqrt{(a^2 + u)(b^2 + u)(c^2 + u)}} \frac{\cos \theta' ds'}{r^2} \tan \theta_0$$

In this the only factor which varies from element to element is

$$\frac{\cos \theta' ds'}{r^2} \tan \theta_0$$

Now $\cos \theta' ds' / r^2$ is the solid angle $d\omega$ subtended at P_1 by the element ds' . We can exhaust the whole of the homœoid by means of elements intercepted by small cones drawn from P as vertex; and to this corresponds precisely an exhaustion of the confocal by small double cones radiating from the internal point P_1 as vertex. And clearly for every elementary cone of solid angle $d\omega$, there exists another in the same plane through PQ , for which the factor just referred to has the same value with opposite

sign. Hence in no plane through PQ is there any force perpendicular to PQ on a unit particle at P ; that is the resultant is along PQ . This is Poisson's theorem.

16. The total force F along PQ (in the direction from P to Q) is given by

$$F = \frac{1}{2}\rho \frac{dk}{k} \int p \frac{\cos \theta_a ds}{r^2} \quad (12)$$

in which the expression to be integrated over the homœoid is the component of attraction along PQ due to the single element ds . If now we use the transformation already employed above, that is, express the co-ordinates of A and P in terms of the co-ordinates of their corresponding points A' and P_1 , A' on the confocal, P_1 on the given shell, and substitute for ds its proper value in terms of the area ds' of the corresponding element on the confocal, the transformed equation is

$$F = \frac{1}{2}\rho \frac{dk}{k} \frac{abc}{\sqrt{(a^2+u)(b^2+u)(c^2+u)}} p_0 \int \frac{\cos \theta'}{r'^2} ds' \quad (13)$$

in which the integral is now taken over the confocal. The only variable factor is now $ds' \cos \theta' / r'^2$, and it is well known that for the complete confocal shell

$$\int \frac{ds' \cos \theta'}{r'^2} = 4\pi$$

since the point P_1 is within it. Hence if V be the potential at P (13) becomes

$$F = -\frac{dV}{dn} = 2\pi\rho \frac{dk}{k} \frac{abc}{\sqrt{(a^2+u)(b^2+u)(c^2+u)}} p_0 \quad (14)$$

where dn is an infinitesimal step outward along the normal at P to the confocal. But by the equation of the confocal [see also § 29]

$$dn = \frac{1}{2} \frac{k}{p_0} du$$

and (14) becomes

$$-dV = \pi\rho abc \frac{dk du}{\sqrt{(a^2+u)(b^2+u)(c^2+u)}} \quad (15)$$

The potential V of the homœoid at P , and at any other point of the confocal surface is thus given by

$$V = \pi\rho abc dk \int_{\lambda}^{\infty} \frac{du}{\sqrt{(a^2+u)(b^2+u)(c^2+u)}} \quad (16)$$

where u is now supposed to vary in value as we go from confocal to confocal outward from P in the integration: the confocal from which the integration starts is that on which P lies, and λ is the positive root of (7) regarded as a cubic in u . The value of the definite integral is $-V_\infty + V$; and as $V_\infty = 0$, we have (16).

17. We may proceed in precisely the same way when P is within the homœoid. A confocal ellipsoidal surface of equation

$$\Sigma \frac{f^2}{a^2 - u} = k \quad (17)$$

is described through P and the corresponding point P_1 on the shell is taken as before. P is joined to the point A on the shell and P_1 to the corresponding point A' on the confocal. The angle θ_0 is as before between AP and the normal at P , and θ' between P_1A' and the normal at A' and $AP = A'P_1 = r$. If p_0, p' be the lengths of the perpendiculars from the centre on the tangent planes at P and A' , we have as before

$$p' \cos \theta_0 = p_0 \cos \theta'$$

Precisely as in the former case we get for the attraction on a unit particle at P

$$F = \frac{1}{2} \rho \frac{dk}{k} \frac{abc}{\sqrt{(a^2 - u)(b^2 - u)(c^2 - u)}} p_0 \int \frac{\cos \theta'}{r^2} dS' \quad (18)$$

where the integral is to be taken over the confocal. The integral is the total solid angle at P_1 subtended by the confocal, and as P_1 is outside that surface, the solid angle is zero. Hence the force is zero at every point within the shell, and the potential is there uniform. Thus the problem of the attraction of a homœoid is completely solved.

This gives the curious theorem that the value of F at P is, to a constant factor, equal to the potential produced, at any point internal to itself, by a uniform magnetic shell coinciding with the confocal surface. The strength of this shell is proportional to the length of the perpendicular from the centre on the tangent plane to the confocal at the point P , and therefore varies with the position of P on the surface, as does the length of that perpendicular.

A similar theorem holds for a distribution upon any surface whatever, which maintains that surface at uniform potential. The potential which that distribution produces at an external point P is equal to the potential which a magnetic shell, coinciding with

the equipotential surface through P for the same distribution, produces at any point internal to itself. The strength of the shell varies with the position of P , and is inversely proportional to the distance, dn , of P measured along the normal to a chosen neighbouring equipotential surface. This expresses, in fact, the relation (32) below, namely,

$$-\frac{dV}{dn} = 4\pi\sigma$$

This shows that σ is inversely proportional to dn for a constant dV . [See § 27.]

18. For a solid homogeneous ellipsoid which has

$$\sum \frac{x^2}{a^2} = 1$$

for the equation of its surface (15) becomes

$$V = \pi pabc \int_{\lambda}^{\infty} \int_{f(u)}^1 \frac{du dk}{\sqrt{(a^2 + u)(b^2 + u)(c^2 + u)}} \quad (19)$$

where λ [with the same value as in (16)] is the lower limit of the integration with respect to u , and $f(u)$ is a function determining the *smallest* value of k for any value that u may have in the range of integration. But since the integration with respect to u does not come within a surface passing through the given point f, g, h and confocal with the homœoid for any assigned value of k , the smallest value of k for a given value of u , is

$$k = \sum \frac{f^2}{a^2 + u}$$

Thus

$$V = \pi pabc \int_{\lambda}^{\infty} \frac{\left(1 - \sum \frac{f^2}{a^2 + u}\right) du}{\sqrt{(a^2 + u)(b^2 + u)(c^2 + u)}} \quad (20)$$

There would be no difficulty in the application of this method of integration by shells to the formal determination of the potentials of solid ellipsoids or of thick shells of varying density, provided each homœoidal film is of uniform density throughout. If the density ρ vary from shell to shell then for the ellipsoid

$$V = \pi abc \int_0^1 \rho dk \int_{\lambda}^{\infty} \frac{du}{\sqrt{(a^2 + u)(b^2 + u)(c^2 + u)}}$$

But

$$dk = - \left\{ \sum \frac{f^2}{(a^2 + u)^2} \right\} du$$

and when $k=0$, $u=\infty$; likewise when $k=1$ $u=\lambda$, where λ is the positive root of

$$\Sigma \frac{f^2}{a^2+u} = 1$$

regarded as a cubic in u . Therefore

$$V = \pi abc \int_{\lambda}^{\infty} \rho \left\{ \Sigma \frac{f^2}{(a^2+u)^2} \right\} du \int_{\lambda}^{\infty} \frac{du}{\sqrt{(a^2+u)(b^2+u)(c^2+u)}} \quad (20^1)$$

19. The result stated in (20) seems to have been first given by Plana in a "Note sur l'intégrale $\int \frac{dM}{r} = V$ " which appeared in *Crelle's Journal*, vol. xx. (1840). It was given also by Lejeune Dirichlet in the same journal in 1846. His process of demonstration is, however, indirect. The result in (20) is first assumed, and then verified by showing that this value of V satisfies Laplace's differential equation of the potential

$$\frac{d^2 V}{dx^2} + \frac{d^2 V}{dy^2} + \frac{d^2 V}{dz^2} = 0 \quad (21)$$

at every point external to the ellipsoid, and that V vanishes at infinity. This latter fact is important. It is fairly obvious for both the homœoid and the solid ellipsoid. The integral (16) for the homœoid, for example, may be compared with the greater integral obtained by putting for each of a^2 , b^2 , c^2 the value of the smallest. This integral is then evaluated, and it is seen that it vanishes at infinity; a fortiori so does the integral for the homœoid.

20. If the point f , g , h be on the surface of the ellipsoid the value of λ is zero in (16) and (20). In the former case the modified equation gives the potential at every internal point, in the latter case

$$V = \pi pabc \int_0^{\infty} \frac{\left(1 - \Sigma \frac{f^2}{a^2+u} \right) du}{\sqrt{(a^2+u)(b^2+u)(c^2+u)}} \quad (22)$$

for a surface point. The case of an internal point requires examination.

It is easy to show that equation (22) is applicable without change of form to the case in which the point f , g , h lies within the surface of the solid ellipsoid. For let the point be on the homœoidal surface given by

$$\Sigma \frac{f^2}{a^2} = u \quad (23)$$

then the potential is made up of two parts, V_1 due to the ellipsoid internal to the surface (23), and V_2 due to the homœoid of finite thickness external to the point. By (20)

$$V_1 = \pi \rho a b c \mu^{\frac{1}{2}} \int_0^\infty \frac{\left(1 - \Sigma \frac{f^2}{a^2 \mu + u}\right) du}{\sqrt{(a^2 \mu + u)(b^2 \mu + u)(c^2 \mu + u)}},$$

which if we write u' for u/μ and substitute, becomes (accents omitted)

$$V_1 = \pi \rho a b c \int_0^\infty \frac{\left(\mu - \Sigma \frac{f^2}{a^2 + u}\right) du}{\sqrt{(a^2 + u)(b^2 + u)(c^2 + u)}} \quad (24)$$

Again, as may easily be verified

$$\begin{aligned} V_2 &= \pi \rho a b c \int_\mu^1 dk \int_0^\infty \frac{du}{\sqrt{(a^2 + u)(b^2 + u)(c^2 + u)}} \\ &= \pi \rho a b c (1 - \mu) \int_0^\infty \frac{du}{\sqrt{(a^2 + u)(b^2 + u)(c^2 + u)}} \end{aligned} \quad (25)$$

Hence

$$V = (V_1 + V_2) = \pi \rho a b c \int_0^\infty \frac{\left(1 - \Sigma \frac{f^2}{a^2 + u}\right) du}{\sqrt{(a^2 + u)(b^2 + u)(c^2 + u)}} \quad (26)$$

This was verified by Dirichlet by showing that it satisfies Poisson's differential equation

$$\frac{\partial^2 V}{\partial x^2} + \frac{\partial^2 V}{\partial y^2} + \frac{\partial^2 V}{\partial z^2} = -4\pi\rho \quad (27)$$

within the attracting matter, gives continuous values of the force-components dV/dx , dV/dy , dV/dz at the surface, and vanishes for $u = \infty$. Thus (22) and (26) give the solution of the differential equation of the potential for the given distribution of matter, and the known family of equipotential surfaces possessed by each homœoidal part. As has already been remarked it was shown by Lamé that the differential equation could be integrated in these circumstances. It would, however, be outside the scope of the present paper to enter into a discussion of the process. Suffice it to say that any solution which fulfils the conditions indicated above can be proved to be the only one.

21. The lemma stated in § 14 above enables the whole problem

of the ellipsoid to be disposed of very simply; but, so far as merely proving Poisson's theorem of the direction of the attraction is concerned, nothing more elegant has ever been invented than the demonstration published in *Crelle's Journal* (Bd. 12, 1834) by Steiner, immediately after the theorem was announced by Poisson in the memoir of 1833, to which reference has already been made. Steiner's construction is shown in the adjoining diagram. P is the external point and PQ is the normal to the confocal through P to the homœoid of which a section through PQ is given in Fig. 7. A, B are two of the points in which the enveloping cone touches the homœoid, and therefore the line AB is the polar of P with respect to the elliptic section made by

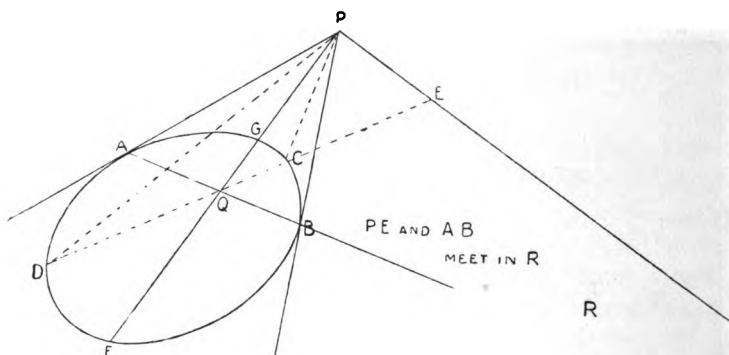


Fig. 7.

the plane BPA . The line PQ meets the curve in G and produced again meets it in F . G, Q are points in which the line, starting from P and ending in F , is divided harmonically. Similarly, if PE be drawn at right angles to PG and meet AQB produced in R , the line RA is also harmonically divided in B and Q . It follows that if EQ meet the curve in C and D , ED is divided harmonically in C and Q . Thus PQ not only bisects the angle APB , but also the angle CPD . Hence $DQ/QC = PD/PC$.

Now let a cone of small vertical angle be drawn from Q as vertex with its axis along CD . It will intercept two elements of the homœoid at C and D , the masses of which are directly as the squares of their distances from Q , while their attractions, per unit of their mass in each case, are inversely as the squares of these

distances. Hence the total attractions on a unit particle at Q are equal and opposite. But it has been seen that $PD/PC = DQ/QC$; hence the attractions of the same pair of elements on a particle at P must be of equal amount, and being along PD and PC are equally inclined to PQ , and have therefore a resultant along that line. The same thing is true for any other pair of elements intercepted by a cone with vertex at Q , and the whole homœoid may be exhausted by pairs of elements in this way. Any plane through PQ thus divides the homœoid into two portions which exert attractions at P equal in amount and equally inclined to PQ .

22. Returning now to the results expressed by equations (16), (20), with lower limit λ or 0, as the case may be, it is obvious that we can change the lower limit of the integral. Thus, taking (16) we write

$$u + \lambda' = u' + \lambda$$

where λ' is positive as well as λ . Then when u is equal to λ , u' is equal to λ' , and the equation becomes

$$V = \pi p a b c d k \int_{\lambda'}^{\infty} \frac{du'}{\lambda' \sqrt{(a^2 + u')(b^2 + u')(c^2 + u')}}.$$

which is of the same form as (16) and the accents on the u 's may be omitted. This proves that two confocal homœoids of equal mass produce the same potential at any point P external to both, that is, that their external fields are identical. If the masses are different, the potentials (and therefore also the field-intensities) at the different points are proportional to the masses.

We shall see presently that this is a particular case of a very general theorem of the potentials of distributions which was given by George Green, of Nottingham, in his celebrated "Essay on the Application of Mathematical Analysis to the Theories of Electricity and Magnetism," published by subscription at Nottingham in 1828.

The substitution used above is also applicable to (20), and gives the result that any two confocal solid ellipsoids produce the same potential at every point external to both. If the masses are different in the two ellipsoids, the potentials at the same external point are proportional to the masses. This is what is usually

called Maclaurin's¹ theorem; but it was only given in its full generality by Laplace many years after Maclaurin's death. It is stated in Maclaurin's *Treatise of Fluxions* [Edinburgh, 1742], § 653, that the attractions of two confocal ellipsoids are the same at all external points which are on the prolongations of the axes. This was a very remarkable result for the time, and though the theorem was only fully generalised by Laplace in his book entitled *Théorie du Mouvement et de la Figure Elliptique des Planètes* [Paris, 1784],² there is some justification for continuing, as has been very generally done, to associate it, even in its extended form, with the name of Maclaurin.

23. From (14) in § 17 above we obtain the components of attraction at the point P . The cosine of the angle which the normal at P to the confocal makes with the semi-axis, of which the length is a , is $p\sqrt{(a^2+u)}/k$. [See (7) § 13.] Hence for the component X of force in the direction of a increasing on a unit particle at P (14) gives

$$X = -2\pi\rho \frac{dk}{k^3} \frac{abcf}{\sqrt{(a^2+u)^3(b^2+u)(c^2+u)}} p^2. \quad (29)$$

Y and Z are obtained by substituting $g/(b^2+u)$, $h/(c^2+u)$ for $f/(a^2+u)$ in this equation. The same results are deducible from (16) by differentiating with respect to u , and multiplying the result by the value of du/df drawn from the equation

$$\Sigma \frac{f^2}{a^2+u} = k$$

of the confocal.

In the same way (20) gives

$$X = -2\pi pabcf \int_{\lambda}^{\infty} \frac{du}{\sqrt{(a^2+u)^3(b^2+u)(c^2+u)}} \quad (30)$$

and similar expressions for Y , Z , which may be written down by

¹ Colin Maclaurin, 1698-1746, Professor of Mathematics in the University of Edinburgh, appointed as assistant and (apparently) successor to James Gregory in 1725. There being a difficulty, through want of funds, in making this arrangement, Newton offered to pay £20 a year if Maclaurin were appointed. Thus Maclaurin was appointed, *Newtono suadente*, as stated in the inscription on his monument.

² This book is referred to by Todhunter in his *History of Attractions*, and he quotes Professor De Morgan as to its rarity. I have not seen it, and give the reference above only at second hand. The University Library has no copy, and though the magnificent edition of Laplace's works, which is now being published in Paris, has reached vol. xiii., this book has not yet been included, though much of later date and on similar subjects has already appeared.

symmetry. In the case of $\lambda=0$, the factors which multiply f, g, h in these expressions for X, Y, Z are independent of the values of these co-ordinates. Hence for an internal point f, g, h of a solid ellipsoid

$$X = Af, Y = Bg, Z = Ch \quad (31)$$

where A, B, C are constants, the values of which are given by (30) and the other two similar equations.

24. I shall now indicate the method which the theory of equivalent distributions affords for the solution of the problem of the ellipsoid. It was shown by Coulomb, for the case of an electrical distribution, that the normal force just outside a closed conductor is proportional to the surface density (attracting or repelling amount of matter per unit area) in the neighbourhood. In the language of the potential this is expressed by the equation

$$-\frac{dV}{dn} = 4\pi\sigma \quad (32)$$

where σ is the surface-density, and dV/dn denotes the rate of variation of potential per unit of distance outwards along the normal. This equation is at once transferable to gravitational attraction, and σ becomes the density of a thin stratum of ordinary matter. Here σ of course denotes the surface density of ordinary matter; e.g. the mass $\rho p d\mathbf{k}/k$ of a homœoid taken per unit area at an element just outside which the normal force dV/dn is taken.

25. This theorem was generalised by Green¹ who showed that if an equipotential surface of any given distribution is known, and the normal components of force at each point of it, it is only necessary to make the distribution indicated by (32) over the surface, in order to obtain precisely the same field external to the

¹ George Green, of Nottingham (1793-1841), was the son of a miller and baker at Sneinton, near Nottingham. His essay on the Application of Mathematical Analysis to the Theories of Electricity and Magnetism, was published by subscription in 1828, and naturally was unknown to the scientific public of the day. It was only in 1850 that Lord Kelvin (then Professor Thomson) having come across a copy of the essay by accident, and finding in it the most remarkable anticipations not only of his own work, but of the theorems of Gauss, Chasles, Sturm, and others, had it published in Crelle's Journal of Pure and Applied Mathematics.

Green gave up the business which he inherited from his father, and was induced to enter as an undergraduate at Cambridge in 1833, to go through (at over forty years of age) the usual curriculum for the Mathematical Tripos! He died prematurely in 1841. No more unsuitable arrangement could have been made to afford a career for the most brilliant mathematical genius of his time: but perhaps it was then the only way of giving him a livelihood and a congenial environment.

equipotential surface as exists in the actual case. The amount of matter thus distributed is precisely equal to the quantity within the surface in the actual distribution. This follows from a theorem usually attributed to Gauss, because given by him in his famous paper of 1840 on "General Theorems regarding Attractive and Repulsive Forces."¹ This is however only a particular case of a very general theorem of analysis given by Green twelve years before, which has done more for physical research than almost any other single theorem of what may properly be called higher mathematics. Green's theorem specialised for the application we are now concerned with shows that if dS be the area of a small element of any closed surface drawn in space in which gravitational action is manifested, N be the normal force outwards at the element, and M be the total quantity of matter *within* the surface, then integrating over the surface we get

$$-\int N dS = 4\pi M \quad (33)$$

Here the unit of mass is supposed to be that which concentrated at a point at unit distance from an equal quantity also at a point, would be attracted by unit force. If the ordinary unit of mass is chosen the equation is

$$-\int N dS = 4\pi \kappa M \quad (33)$$

where κ is the so-called constant of gravitation. This theorem applied to the equipotential surface verifies the statement as to the amount of matter distributed on the equipotential surface according to the law of equation (32). It is very remarkable that the surface integral depends on the quantity of matter within the surface and not on its distribution, and does not depend on the matter outside the surface, though that also is effective in producing the value of N at each point.

26. The term equipotential surface is, of course, as the name implies, a surface at every point of which the potential has the same value. At every point just outside such a surface the resultant attractive force on a particle is normal to the surface; in other words, no work is done by or against gravitation in displacing a particle along the surface. Hence it is more appropriate in the gravitational application to speak of level surfaces, as did Mac-laurin nearly two hundred years ago, not only for the gravitational field of the earth, but also for the fields of other distributions of

¹ Gauss, *Resultate*, 1840, or *Taylor's Scientific Memoirs*, iv.

matter; and the usage is not uncommon in the discussion of fields of electric force. Thus French writers use almost always the phrase “surface de niveau” whatever the nature of the attracting “matter” may be.

The process of contouring, illustrated by the contour lines drawn on a map, enables the field in any case to be exhibited in all its characteristics. Let the level surfaces be drawn in the field for equal small steps of potential (that is equal small differences of level) then where the successive surfaces crowd more closely together, the potential varies more quickly from surface to surface, that is the field-intensity (which is measured for any direction by the space rate of variation of the potential in that direction) is there greater, and *vice-versa*. In the same way the crowding together of contour lines on a map shows where a mountain slope is steepest, where two or more lines touch one another we know that the cliff is vertical, and where an upper contour line laps over a lower that the cliff overhangs. The slope in a map may be measured by the drop in gravitational potential per unit of horizontal displacement from one line to the next, or since outside and near the earth's surface gravitational potential falls off by equal amounts for equal vertical descents, the slope may be measured as it usually is, by the ratio of vertical drop to horizontal displacement.

Gravitational force on a unit particle at a point, or intensity of field, is potential slope, and is measured numerically by the ratio of the change of potential dV , from one level surface to an adjacent one, to the distance along the normal from one surface to the other: the sign depends on whether dV is an increase or a diminution of V . Thus if dn be this small space step, dV/dn is the force or field intensity.

27. I shall not discuss the properties of level surfaces here; but merely apply some of the properties I have mentioned to the problem of the ellipsoid. But a theorem of Bertrand may be mentioned of which our process will afford an illustration. Let there be a family of surfaces represented by the equation

$$f(x, y, z) = \alpha \quad (34)$$

where α is a variable parameter; and let them be such that if a distribution of matter be placed on the surface, S say, characterised by any chosen value of α , and be made of surface density inversely proportional to the distance from that surface to an adjacent one of the family the whole space within the surface is at uniform

potential. Then the surfaces external to S are level surfaces for the distribution specified.

The truth of this theorem may be seen as follows. Let the distribution specified be made on an inner surface, S_1 say, of the family: the space within is at uniform potential, and therefore so also are all points of the surface. But if σ be the density at any point of the surface, then just outside

$$-\frac{dV}{dn} = 4\pi\sigma$$

Now the step from the surface S_1 to an adjacent one S_2 may be taken as dn , and being inversely proportional to σ gives a constant difference of potential between S_1 and S_2 . Hence S_2 is a level surface for the distribution on S_1 . Let now the distribution be transferred to S_2 , and be made according to the law set forth in (32) for the values of dV/dn which exist at S_2 with the distribution on S_1 . Since S_2 is a level surface for the distribution on S_1 , the transference thus effected will bring the whole space within S_2 to uniform potential equal to that which existed at S_2 before the transference. But the surface S_2 is by hypothesis one over which a distribution can be made of density inversely proportional at the different points to the normal step to an adjacent surface S_3 , and producing uniform potential in the interior. If the mass in this latter distribution be made the same as that which has been transferred from S_1 , the potentials at S_2 and within it produced in the two cases will be the same. For it can be proved¹ that there cannot be two distributions of a given charge of matter over a surface so as to produce uniform potential at all parts on or within the surface.

The distribution therefore transferred from S_1 must have the same density as in the other case supposed, that is σ must be inversely proportional to the step from S_2 to S_3 . S_3 is a level surface and the change can now be transferred to S_3 , when S_4 will be found to be a level surface and so on. Hence Bertrand's theorem is proved. It is easy to construct (see Picard, *Traité d'Analyse* tome i.) an analytical proof of the theorem, founding on Lamé's theorem of the integration of Laplace's equation for a given system of level surfaces.

¹ This is one of a set of theorems as to the uniqueness of solutions of potential problems. The proof will be found in treatises on Electricity or on Gravitational Attraction.

28. In the transference of matter imagined in the last article the particles may be regarded as carried out along trajectories, cutting the successive surfaces at right angles. Thus, if we draw these trajectories from points in the periphery of ds_1 , they will mark out elements ds_2, ds_3 , etc., on the successive surfaces. The matter first on ds_1 will be carried to ds_2 , then to ds_3 , and so on; and this law will hold however small ds_1, ds_2 , etc., may be made.

Let now this process be applied to the elliptic homœoid discussed above. It is plain that we may take as σ the value $\frac{1}{2} \rho p dk/k$, which gives us the result

$$-\frac{dV}{dn} = 2\pi \rho p \frac{dk}{k} \quad (35)$$

But if m denote the total mass of the homœoid

$$m = \frac{1}{2} \rho \frac{dk}{k} \int p ds = 2\pi \rho abck^{\frac{1}{2}} dk \quad (36)$$

since $\int p ds$ is three times the volume of the homœoid, that is, $4\pi abck^{\frac{3}{2}}$. Thus we obtain $dk/k = m/2\pi \rho abck^{\frac{3}{2}}$ and

$$-\frac{dV}{dn} = \frac{m}{k^{\frac{3}{2}}} \frac{p}{abc} \quad (37)$$

From (37) it follows that the work done against attraction in carrying a unit particle outwards through a small distance dn along the normal is

$$-dV = \frac{1}{k^{\frac{3}{2}}} \frac{m}{abc} p dn \quad (38)$$

29. If then dn be taken for different points of the surface so that $p dn$ is constant, there will be the same step of potential at every point, and the surface on which lie the extremities of these elements, dn , of the normals will be, like the surface of the homœoid, an equipotential or level surface. The distance between this surface and that of the homœoid is inversely proportional to p . It can in fact be shown very easily that the shell of space between the surfaces is a *focaloid*, to use the name given by Thomson and Tait to a space bounded by confocal ellipsoidal surfaces. For the equation of an ellipsoidal surface external to and near to the external surface of the homœoid $\Sigma(x^2/a^2) = k$, is

$$\Sigma \frac{x^2}{a^2 + du} = k$$

where du is small, and x, y, z are the co-ordinates of a point on the new surface. If for x, y, z in the last equation we write

$x + dx$, $y + dy$, $z + dz$, and subtract from the result $\Sigma(x^2/a^2) = k$, we obtain for the thickness dn at x, y, z of the shell of space

$$\frac{p}{k} \Sigma \left(\frac{x dx}{a^2} \right) = dn = \frac{1}{2} \frac{k}{p} du \quad (39)$$

Thus the equipotential surface given by dn thus chosen is confocal with the surface of the homœoid.

30. Let us now imagine the mass of the homœoidal shell carried out along the normal at each point, and distributed on the near confocal surface, so that the mass on any element ds of the shell is placed on the element ds' which is marked off by normals drawn from the periphery of ds . The shell thus formed will, by Green's principle of equivalent distributions, be a new homœoid which will give the same field external to itself as was produced by the original shell. For, take the tubular space marked out by normals drawn from the periphery of ds , and terminated by two caps, one just inside ds , but otherwise coinciding with it, the other outside ds' , and fitting closely to that element. The surface of this portion of space is the lateral surface, the inner cap, and the outer. Now take the integral of normal force $\int N ds$ over the whole surface of this space. The inner cap contributes nothing to it since there is no force within the homœoid, the lateral surface also contributes nothing, the outer cap gives $F' ds'$ if F' be the field-intensity there. The matter within the space is σds , and therefore by Green's theorem (§ 25) $F' ds' = -4\pi\sigma ds$. But if matter were distributed over ds' , and similarly over the rest of the surface of the confocal, so that the field remained unaltered, the surface integral over the short tube just described, would still be $F' ds'$, and the matter on ds' would now be σds . This distribution is unique for the given level surface, and the given field external to it. Since the surface S' is ellipsoidal, and the potential is constant within it, the distribution upon it effected as described by carrying the matter out from the initial homœoid is also homœoidal; otherwise the distribution over the surface producing uniformity of potential would not be, as it can be proved to be, unique.

It is easy to verify this latter point as to the nature of the distribution. The matter on ds' is now σds , and for σ we may write βp where β is a constant. Hence the new surface density $\sigma' = \beta p ds/ds'$. But if p' be the length of the perpendicular from the centre for ds' , and $a', b', c' = \sqrt{a^2 + du}, \sqrt{b^2 + du}, \sqrt{c^2 + du}$, we

have $p'ds' = p'dsa'b'c'/abc$, so that $\sigma' = \beta p'abc/a'b'c'$, thus σ' varies as p' , that is, the distribution is homœoidal.

We can now imagine a further step of potential taken from the surface S' to a succeeding confocal and so on, until we have carried the whole distribution of matter to a surface, every point of which is at an infinite distance from the original surface. There the surface density will be zero, and the potential at infinity, which has not been altered by the transference, will be zero. It is thus seen that the equipotential surfaces of the external field of the original homœoid are ellipsoids confocal with the original homœoid, a well-known result which has been otherwise established above.

The matter in the transference passes from confocal to confocal, so that the matter on an element of one is carried to the corresponding element on the next, and so on. Thus at any stage of the transference when the distribution is on a given confocal the matter which was originally on the element ds of the original homœoid is situated on the element of the confocal which corresponds to ds . The transference is along the hyperbolas which are the orthogonal trajectories of the confocals, or, as they are often called, the lines of force of the field.

31. Another way of dealing with this problem of equivalent distributions is to apply the theorem of Bertrand discussed in § 27. The initial distribution is an elliptic homœoid, and we know that the family of confocal surfaces surrounding it fulfil the condition stated in Bertrand's theorem. For upon any one of them a homœoidal distribution can be placed so as to produce a constant potential throughout its interior. Hence the confocals are the level surfaces of the field of the original homœoid. Hence also we can suppose the whole distribution carried out from confocal to confocal, so that at each instant the distribution is homœoidal on one of the level surfaces, and the path of each particle is along the line of force at the inner extremity of which it was originally situated.

32. We have found [§28, equation (38)] the step of potential from the initial surface to an adjacent one of which the equation is

$$\Sigma \frac{x^2}{a^2 + du} = k$$

and it is proved in § 29 that $dn = \frac{1}{2}kdu/p$. Thus (38) becomes

$$-dV = \frac{1}{2\sqrt{k}} \frac{m}{abc} du$$

In the same way the step of potential from the level surface

$$\Sigma \frac{x^2}{a^2 + u} = k$$

to the adjoining surface for which u has been increased by du is

$$-dV = \frac{1}{2\sqrt{k}} \frac{mdu}{\sqrt{(a^2 + u)(b^2 + u)(c^2 + u)}} \quad (40)$$

Integrating from $u=0$ to $u=\infty$, and observing that the integral must vanish at infinity, we have

$$V = \frac{m}{2\sqrt{k}} \int_0^\infty \frac{du}{\sqrt{(a^2 + u)(b^2 + u)(c^2 + u)}} \quad (41)$$

If in this we insert the value of m stated in (36) it becomes

$$V = \pi p a b c d k \int_0^\infty \frac{du}{\sqrt{(a^2 + u)(b^2 + u)(c^2 + u)}} \quad (42)$$

If in (42) we change u to $u - u'$ we obtain

$$V = \pi p a b c d k \int_{-u'}^\infty \frac{du}{\sqrt{(a^2 + u - u')(b^2 + u - u')(c^2 + u - u')}} \quad (43)$$

which is to be interpreted as the total step of potential involved in carrying the matter, supposed initially in a thin homœoid (mass m) of which the equation is $\Sigma \{x^2/(a^2 - u')\} = k$ from the level surface $\Sigma x^2/a^2 = k$ to infinity in the manner described. Thus matter m distributed in a homœoid on the latter surface has the same potential at the surface and at all external points as the same matter had when in the original homœoid. This is for confocal homœoids what Maclaurin's theorem is for solid ellipsoids, and indeed Maclaurin's theorem flows from it at once since a solid ellipsoid may be supposed built up of a succession of homœoids. It is to be observed, however, that this theorem of equivalence of homœoids on confocal surfaces, is only a particular case of Green's very general theorem of equivalence. Maclaurin's theorem and the analogous theorems for shells have been explained in § 22, and it is not necessary to pursue the subject here. In § 18 the extension for a shell to a solid ellipsoid has also been fully discussed.

33. The potential of a thin homœoid at a point on its surface or anywhere in the interior is given in (42). From this we can obtain the potential of a thick homœoid at a point within the

interior hollow. We shall suppose that the equations of the outer and inner surfaces are respectively

$$\Sigma \frac{x^2}{a^2} = 1, \text{ and } \Sigma \frac{x^2}{a^2} = h.$$

We have therefore only to integrate (42) with regard to h from $h = h$ to $h = 1$. Thus for the thick homœoid

$$V = \pi p a b c (1 - h) \int_0^\infty \frac{du}{\sqrt{(a^2 + u)(b^2 + u)(c^2 + u)}} \quad (44)$$

The potential produced by this homœoid at an external point may be found as follows: The squares of the semi-axes of the interior ellipsoidal hollow are $a^2 h$, $b^2 h$, $c^2 h$, where $h < 1$. The potential V' at the external point f, g, h due to an ellipsoid of density ρ filling the hollow is given by

$$-V' = \pi p a b c h^{\frac{3}{2}} \int_{\lambda_1}^\infty \frac{\left(1 - \Sigma \frac{f^2}{a^2 h + u_1}\right) du_1}{\sqrt{(a^2 h + u_1)(b^2 h + u_1)(c^2 h + u_1)}} \quad (45)$$

where λ_1 is the positive root of the equation

$$\Sigma \frac{f^2}{a^2 h + u_1} = 1$$

If in (45) we write uh for u , we get

$$V' = \pi p a b c \int_{\lambda'}^\infty \frac{\left(h - \Sigma \frac{f^2}{a^2 + u}\right) du}{\sqrt{(a^2 + u)(b^2 + u)(c^2 + u)}} \quad (46)$$

where $\lambda' = \lambda_1/h$. The potential at the external point f, g, h due to the complete ellipsoid is given by (20) [§ 18]. Subtracting (46) from (20) we obtain for the thick homœoid

$$V = \pi p a b c \left[\int_{\lambda}^{\lambda'} \frac{\left(1 - \Sigma \frac{f^2}{a^2 + u}\right) du}{\sqrt{(a^2 + u)(b^2 + u)(c^2 + u)}} + (1 - h) \int_{\lambda'}^\infty \frac{du}{\sqrt{(a^2 + u)(b^2 + u)(c^2 + u)}} \right] \quad (47)$$

When the internal hollow is contracted to zero, that is when $h = 0$, λ' becomes ∞ , and the second integral on the right vanishes. The equation then coincides with (20) as it ought to do.

34. We can now find the potential produced by a thick focaloid at an external or internal point. First for an external point : let two confocal ellipsoids have the same density, and let the shell between their surfaces be the focaloid to be considered. The potentials which they produce at a point external to both are in the ratio of the masses of the ellipsoids. For the potential of that which has $\Sigma(x^2/a^2) = 1$ for the equation of its surface the equation is (20) [§ 18 above], and for the potential of the other which has, let us say, $\Sigma\{x^2/(a^2 - s)\} = 1$ for the equation of surface, the equation is the same with as multiplier of the integral $\pi\rho\sqrt{(a^2 - s)(b^2 - s)(c^2 - s)}$ instead of $\pi\rho abc$. Thus for the potential of the focaloid at an external point f, g, h we obtain

$$V = \frac{3}{2}m' \int_{\lambda}^{\infty} \frac{\left(1 - \Sigma \frac{f^2}{a^2 u}\right) du}{\sqrt{(a^2 + u)(b^2 + u)(c^2 + u)}} \quad (48)$$

where m' is put for the mass of the focaloid, that is

$$\frac{4}{3}\pi\rho\{abc - \sqrt{(a^2 - s)(b^2 - s)(c^2 - s)}\}.$$

This equation is precisely the same as (20) which gives the potential at an external point for a solid ellipsoid : and just as in the case of ellipsoids it follows that :—any two uniform focaloids which are confocal with the same ellipsoid produce, at any point external to both, potentials which are in the ratio of the masses of the focaloids.

This theorem was practically given for points in the axes of an ellipsoid of revolution by Maclaurin. For he states [*Fluxions* Art, 650], with the same limitations, the remarkable result that an ellipsoid made up of confocal shells each of uniform density, differing from shell to shell, and an ellipsoid of the same size and of uniform density, exert attractions on an external particle which are in the same direction, and have values in the same ratio as the masses of the ellipsoids.

The theorem becomes generalised by the extension of Maclaurin's theorem by Laplace to any form of ellipsoid and any external point. Obviously in the theorem just stated for a heterogenous ellipsoid, the ellipsoids compared need not be of the same size but only confocal.

35. If the point f, g, h considered be in the hollow within the focaloid the potential can be found by subtracting from the expression for the potential at the point due to the complete

ellipsoid, the potential at the same point due to the solid ellipsoid of the same density bounded by the surface $\Sigma\{x^2/(a^2-s)\} = 1$, the internal surface of the focaloid. Making this calculation by (22), and putting in the result m' (see § 34) for the mass of the focaloid, we get

$$V = \frac{3}{4}m' \int_0^\infty \frac{\left(1 - \Sigma \frac{f^2}{a^2+u}\right) du}{\sqrt{(a^2+u)(b^2+u)(c^2+u)}} - \frac{3}{4}(m-m') \int_{-s}^0 \frac{\left(1 - \Sigma \frac{f^2}{a^2+u}\right) du}{\sqrt{(a^2+u)(b^2+u)(c^2+u)}} \quad (49)$$

In the remaining case, that in which the point f, g, h is within the mass of the focaloid, the procedure is exactly the same as that just described. The form of the result is slightly different: it is

$$V = \frac{3}{4}m' \int_0^\infty \frac{\left(1 - \Sigma \frac{f^2}{a^2+u}\right) du}{\sqrt{(a^2+u)(b^2+u)(c^2+u)}} - \frac{3}{4}(m-m') \int_{\lambda'-s}^0 \frac{\left(1 - \Sigma \frac{f^2}{a^2+u}\right) du}{\sqrt{(a^2+u)(b^2+u)(c^2+u)}} \quad (50)$$

where λ' is the positive root of $\Sigma\{f^2/(a^2-s+u)\} = 1$, regarded as an equation in u . When $\lambda' = 0$ the point f, g, h lies on the internal surface of the focaloid. Then (50) agrees with (49).

36. It is interesting to compare equations (42) and (49). The first gives the potential produced at any internal point by a thin elliptic homœoid of mass m , and (49) gives that of a focaloid of mass m at an internal point f, g, h . If we put $f=g=h=0$, we get the potentials at the centre in the two cases. Let it be supposed that both shells are thin, and that both have the same external surface. The thickness of the homœoid being directly, and that of the focaloid inversely, as the length of the perpendicular let fall from the centre on the tangent plane at the point considered, the potential at the centre must be greater for the focaloid than for the homœoid. The first term on the right of (49) involves for the centre the same integral as does (41) for the homœoid, but this integral is multiplied by $\frac{3}{4}m'$ in (49) as

against $\frac{1}{2}m$ in (41). The excess is diminished by the second term in (49) which varies with the deviation of the surface from sphericity; and also with the thickness of the focaloid on the whole.

In the particular case in which the surface is spherical the second term just makes the potential at the centre the same for a thin focaloid as for a thin homœoid, as the reader may verify by evaluation. If we take the case of a solid ellipsoid the second term in (49) vanishes, and the potential at the centre is $\frac{3}{2}$ of that which would be produced in the interior of a thin homœoid of the same mass and coincident with the surface of the ellipsoid.

37. From the expression given in (44) for the potential in the interior of a homœoid of any thickness, we can readily calculate the work done by gravitational attraction in bringing together from infinite dispersion in space the matter composing an ellipsoid, or a homœoid of finite thickness, whether uniform or made up of homœoidal shells of different densities. For the case of uniform density, let mass of amount $2\pi\rho abc h^{\frac{1}{2}} ah$, be brought from infinity to the homœoid to which (44) refers, and be placed as an additional thin homœoid on the interior surface. The work done by gravitational attraction in bringing this matter into position is Vm . Hence

$$Vm = 2\pi^2\rho^2 a^2 b^2 c^2 h^{\frac{1}{2}} (1-h) d h \int_0^\infty \frac{du}{\sqrt{(a^2+u)(b^2+u)(c^2+u)}} \quad (51)$$

If then W denote the whole work done in building up the homœoid by adding to the interior until h is changed from 1 to H , or

$$\begin{aligned} W &= -2\pi^2\rho^2 a^2 b^2 c^2 \int_H^1 h^{\frac{1}{2}} (1-h) d h \int_0^\infty \frac{du}{\sqrt{(a^2+u)(b^2+u)(c^2+u)}} \\ &= 2\pi^2\rho^2 a^2 b^2 c^2 \left\{ \frac{4}{15} - \frac{2}{3} H^{\frac{1}{2}} \left(1 - \frac{3}{5} H \right) \right\} \int_0^\infty \frac{du}{\sqrt{(a^2+u)(b^2+u)(c^2+u)}} \quad (52) \end{aligned}$$

If $H=0$, this becomes the result for a solid ellipsoid.

For this case

$$W = \frac{8}{15} \pi^2 \rho^2 a^2 b^2 c^2 \int_0^\infty \frac{du}{\sqrt{(a^2+u)(b^2+u)(c^2+u)}} \quad (53)$$

In the particular case of a uniform sphere this becomes

$$W = \frac{3}{8} \frac{M^2}{a}$$

if the unit of mass is gravitational (see § 6, footnote), or

$$W = \frac{3}{8} \kappa \frac{M^2}{a}$$

if the ordinary unit of mass is used and κ is the proper value of the gravitational constant. This is the result given by Helmholtz, from which the rate of shrinking of the sun necessary to supply the energy radiated may be calculated.

If the density vary from shell to shell (53) becomes

$$W = 2\pi^2 a^2 b^2 c^2 \int_0^1 \rho \frac{dh}{h} \int_h^1 \rho dk \int_0^\infty \frac{du}{\sqrt{(a^2 + u)(b^2 + u)(c^2 + u)}} \quad (54)$$

as the reader may verify by finding the work done in building up a thick homœoid by adding shells of varying density ρ , and then varying the constant h of this homœoid from 0 to 1.

RULES GOVERNING THE COMPETITION FOR THE GRAHAM MEDAL.

1. The competition for the Graham Medal shall be under the authority and control of the Council of the Royal Philosophical Society of Glasgow, whose decision on all points connected therewith shall be final.

2. Each candidate shall forward to the Secretary of the Royal Philosophical Society of Glasgow, 207 Bath Street, Glasgow, on or before 14th March of the year in which the competition is held, a paper giving an account of an unpublished original research conducted by himself in any branch of chemical science.

3. The medal shall be awarded to the candidate whose research, in the opinion of the Council, or of the person or persons whom they may appoint to adjudicate in the matter, is of the highest merit, and most likely to aid in the advancement of chemical science.

4. The successful candidate shall read the paper, on account of which the medal is awarded, to the Royal Philosophical Society of Glasgow. The paper shall thereafter be published in the *Proceedings* of the Society, and its publication elsewhere shall not take place without the permission of the Council.

5. No award shall be made if, in the opinion of the Council, no candidate has contributed a paper of sufficient merit.

MINUTES OF SESSION.

1905-1906.

1st November, 1905.

The First Ordinary Meeting, for Session 1905-1906 of the Royal Philosophical Society of Glasgow, was held within the Rooms, 207 Bath Street, on the evening of Wednesday, 1st November, 1905, at 8 o'clock. The President, Dr David Murray, occupied the chair.

1. The Hon. Secretary intimated that no Minute would be read, as that for the previous Meeting was published in the last issue of the *Proceedings*, and had been read and approved at the close of the Meeting itself.

2. The Chairman intimated that an Agreement had been drawn up and executed, subject to confirmation of the Society, whereby the Society would, if the Agreement were confirmed, acquire the interest of the Engineers and Shipbuilders in the joint buildings, for the sum of £4,000. Full details, he said, would be in the hands of Members before next meeting.

3. The Chairman drew attention, in connection with the subject of the lecture about to be delivered, to the recent deaths of Dr Copland, Astronomer Royal for Scotland, and of Mr John Dansken, President of the local branch of the Royal Astronomical Society, and a Member of the Society.

4. Mr H. A. Mavor, M.Inst. C.E., delivered a lecture entitled, "A Solar Eclipse Expedition," being a communication from the Geographical and Ethnological Section. The lecture was illustrated with lantern views.

Professor L. Becker, Ph.D., exhibited and explained the Siderostat used during the eclipse and also the apparatus he had devised and used for automatically timing the exposures in taking the photographs, which it was the purpose of the Expedition to obtain. A few of the photographs were shown on the screen.

Dr Erskine Murray produced by electrical means an imitation of the Corona as seen during the eclipse at the instant of totality.

VOL. XXXVII.

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On the motion of the Chairman Mr Mavor, Professor Becker, and Dr Erskine Murray were accorded a vote of thanks.

5. The Chairman announced that the following gentlemen had been duly elected to Membership of the Society :—

1. Mr. JAMES BOYD, Master Ironmonger, Boydston, Lenzie. Recommended by Mr J. Craig Annan, Dr Freeland Fergus, and Professor Peter Bennett.
2. Mr D. S. CARSON, C.A., J.P., St Oswalds, Kilmacolm. Recommended by Dr David Murray, Mr John Mann, Jun., and Professor G. G. Henderson.
3. Mr ALAN E. CLAPPERTON, Writer, 91 West Regent Street. Recommended by Dr David Murray, Mr H. F. Stockdale, and Professor Thomas Gray.
4. Sir THOMAS GLEN COATS, Bart., Ferguslie Park, Paisley. Recommended by Dr David Murray, Mr H. F. Stockdale, and Dr Freeland Fergus.
5. Mr DAVID COOPER, Railway Manager, 18 Kingsborough Gardens, Kelvinside. Recommended by Dr David Murray, Dr Oswald Fergus, and Professor G. G. Henderson.
6. Mr JOHN W. FYFE, F.S.I., Surveyor and Measurer, 221 West George Street. Recommended by Mr William Fraser, Mr. John Mann, Jun., and Dr David Murray.
7. Mr H. A. HEDLEY, 9 Derby Crescent, Kelvinside. Recommended by Professor Archibald Barr, Dr David Murray, and Mr James MacLehose.
8. Mr THOMAS N. HILL, F.S.I., Surveyor and Measurer, 180 Hope Street. Recommended by Mr William Fraser, Mr John Mann, Jun., and Dr David Murray.
9. Mr ROBERT KEDIE, Merchant, Anstane, 11 Eglinton Drive, Kelvinside. Recommended by Dr David Murray, Mr H. F. Stockdale, and Professor Magnus Maclean.
10. Mr ROBERT KING, Merchant, 115 Wellington Street. Recommended by Dr David Murray, Dr George Neilson, and Dr Freeland Fergus.
11. Sir ARCHIBALD C. LAWRIE, LL.D., The Moss, Dungoyne, Stirlingshire. Recommended by Dr George Neilson, Mr James MacLehose, and Dr David Murray.
12. Mr WILLIAM LOBBAN, M.A., 48 University Avenue, Hillhead. Recommended by Dr George Neilson, Mr J. T. T. Brown, and Mr John Clark.
13. Mr JAMES LUMSDEN, Arden House, Arden, Dumbartonshire. Recommended by Dr David Murray, Professor Magnus Maclean, and Dr Oswald Fergus.
14. Mr JOHN MACFEE, M.I.E.E., General Manager, Corporation Telephones, 65 Renfield Street. Recommended by Professor Magnus Maclean, Mr H. F. Stockdale, and Professor Peter Bennett.

15. Mr. ALEXANDER MACKENDRICK, Photographer, 518 Sauchiehall Street. Recommended by Mr J. Craig Annan, Mr James MacLehose, and Mr John Mann, Jun.
16. Mr ROBERT MACKENZIE, Writer, 176 St Vincent Street. Recommended by Dr David Murray, Professor Magnus Maclean, and Dr Freeland Fergus.
17. Mr JAMES MAIN, The Rowans, Bothwell. Recommended by Mr J. M'Elligott, Mr James S. Morton, and Dr Freeland Fergus.
18. A. L. MELLANBY, D.Sc., Professor of Motive Power Engineering, The Technical College, Glasgow. Recommended by Professor Peter Bennett, Professor Thomas Gray, and Professor Magnus Maclean.
19. Mr JOHN NISBET, Architect and Surveyor, 112 Bath Street. Recommended by Mr William Fraser, Dr David Murray, and Mr Thomas S. Fraser.
20. Mr A. S. MURRAY, Writer, 169 West George Street. Recommended by Dr David Murray, Dr George Neilson, and Professor Peter Bennett.
21. Mr R. A. MURRAY, C.A., 175 West George Street. Recommended by Dr David Murray, Mr John Mann, Jun., and Mr John Clark.
22. Mr FRITZ ROTTENBURG, Merchant, 55 West Regent Street. Recommended by Dr David Murray, Professor Magnus Maclean, and Dr Freeland Fergus.
23. Mr ARCHIBALD D. WYLLIE, Writer, 1 Minard Terrace, Partickhill. Recommended by Dr David Murray, Professor Magnus Maclean, and Dr Oswald Fergus.
24. Mr A. BONAR LAW, Kintillo, Helensburgh. Recommended by Dr David Murray, Dr George Neilson, and Dr Freeland Fergus.

REPORT OF COUNCIL FOR SESSION 1904-1905.

I. *Meetings of the Society.*—Session 1904-1905 was opened on the 2nd November, 1904, by Professor E. A. Schäfer, of Edinburgh University, with a lecture on "Artificial Methods of Respiration." Twelve meetings were held at which sixteen communications were made, twelve of which are printed in the *Proceedings*.

II. *Centenary Lectures.*—The marked success of the lectures on "The Development of Science during the Nineteenth Century," given in the previous session, encouraged the Council to arrange for the delivery of a second series in 1904-1905. The result was in accordance with expectation, and amply justified the making of the experiment. Four lectures were given, viz., (1) "Developments of Electric Signalling during the Nineteenth Century," by Professor Magnus Maclean; (2) "The Progress of Astronomy in the Nineteenth Century," by Professor L. Becker; (3) "The Evolution of Zoology during the Nineteenth Century," by Professor J. Graham Kerr; (4) "Development of Sanitation during the Nineteenth Century," by Dr A. K. Chalmers.

III. *The Sections.*—The Sections continue to be well organised by energetic officials and produce excellent work. Eight of the seventeen papers printed

in the *Proceedings* for the Session were contributions from the Sections, and represent but a small fraction of the whole work done. The Historical and Philological, and the Architectural Section were able to issue complete syllabuses early in the Session.

As a result of representation made to the Council steps were taken to revive the Biological Section. Office-bearers of the Section, with Professor Bower as President, were appointed, and the approval of the Society obtained.

IV. *The Proceedings*.—Volume XXXVI, of the *Proceedings* will be ready for issue to members about the middle of November. The book contains the transactions of the Society for Session 1904-1905. Seventeen of the communications made to meetings of the Society or of the Sections are printed in full. They are fairly representative of the various interests of members, and include very valuable results of original and research work. Other papers read are withheld meantime by desire of the authors.

V. *The Joint-Property*.—Just before the beginning of Session 1904-1905 the Council was approached on behalf of the Engineers and Shipbuilders with the view of dissolving the Joint ownership in the Buildings, 207 Bath Street, on the ground that these no longer afforded sufficient or suitable accommodation for both Societies. Negotiations thus commenced resulted in an offer by the Engineers either to buy the share of the Society in the joint-property, or to sell their own to the Society for the sum of £4,000. The Council chose the latter alternative as being, in their opinion, the more favourable for the Society; and eventually an Agreement, in which details were adjusted to the satisfaction of both parties, was drawn up and executed subject to the confirmation of the two Societies. The Agreement, if confirmed, becomes operative at Martinmas 1905, and interest on the purchase money (£4,000), from that date till Candlemas 1906, is to be at $3\frac{1}{2}$ per cent. By a clause of the Agreement the Engineers are to have the use of the Buildings, attendance and other facilities as at present for a period of two years for an annual payment of £220.

VI. *The Graham Medal*.—No award was made.

VII. *The Library*.—The report of the Library Committee follows separately. The Hon. Librarian, Mr John Robertson, was able to announce in last report that the new Catalogue of the Library was ready for issue. The Society signified its appreciation of the labour and time expended in compiling the Catalogue, and its satisfaction with the result, by passing a special vote of thanks to Mr Robertson, and awarding him an honorarium of fifty guineas.

VIII. *Membership*.—During the Session, 24 Members were elected, and 1 was reinstated from the Suspense List. One Honorary Member was elected, viz.—Sir Wm. Ramsay. Fifteen have resigned, 16 have died. The following are the deaths, viz.—James Chisholm, Sir John Neilson Cuthbertson, G. Handasyde Dick, Robert Glen, James Hunter, A. D. M'Nair, John Mayer, Thos. P. Miller, Jas. Napier, Geo. Parker, Rev. A. Rattray, Wm. Robertson, H. L. Seligmann, Geo. Smellie, Jas. Thomson and Prof. R. S. Thomson, five of whom were Life Members. Of the New Members admitted during the Session, 5 qualified themselves as Life Members, and 8 Old

Members likewise qualified. There are now 290 Members of that class out of 349 who have so enrolled themselves. The roll now includes 17 Honorary Members, 19 Corresponding Members, and 944 Ordinary Members (Annual and Life), or a total of 980.

IX. *Finance*.—The Treasurer's statement for 1904-1905 shows an excess Revenue of £75 13s. 11d. against £301 5s. 8d. last year—arising mainly from the expenditure on the New Catalogue for the Library.

The Society's investments are shown in detail in the Balance Sheet, the Capital at 30th Sept., 1905, being £4,796 19s. 11d., irrespective of the value of the Library.

Separate statements are given by the Treasurer, as formerly, showing the position of the two funds which the Society holds in trust, viz.—“The Graham Medal and Lecture Fund” and “The Glasgow Science Lecture Fund,” the balances of revenue being £90 5s. 10d. and £61 1s. 3d. respectively.

REPORT OF THE LIBRARY COMMITTEE.

The Library Committee have to report that during last year 1,245 books were issued by the Librarian.

Exclusive of periodicals, 42 volumes and 22 parts of works were added to the Library by purchase, and 58 volumes, 17 parts of works and 29 pamphlets were presented.

The Periodicals received at the Library numbered 108, of which 68 were bought and 40 were sent in exchange.

The *Proceedings* of the Society were forwarded to 189 societies and public bodies. and 176 volumes and 137 parts of works were received in exchange. These included 39 volumes of Abridgments of Specifications of Patents.

Altogether during the year there were added to the Library 395 volumes, 126 parts of works and 29 pamphlets. The number of complete volumes, exclusive of pamphlets, now reaches a total of 15,790.

Since last report 261 volumes have been bound.

The Natural History Department of the British Museum, the Columbus State University and the Glasgow Institute of Accountants and Actuaries have been added to the list of exchanges.

In Volume XXXVI. of the *Proceedings* there will be found a list of the Additions to the Library by purchase during the year; the titles of the books presented with the names of the donors; the names of the societies, etc., with which exchanges are effected and a list of the periodicals received at the Library.

JOHN ROBERTSON, Hon. Librarian,
Convener.

15th November, 1905.

An Extraordinary General Meeting of the Members of the Royal Philosophical Society of Glasgow, duly convened for the

purpose of considering and, if so resolved, of passing the Resolution hereinafter mentioned, was held in the Rooms of the Society, 207 Bath Street, on the 15th day of November, 1905, at 7.45 p.m. The chair was occupied by the President, Mr David Murray, LL.D.

It was agreed that the notice calling the Meeting should be held as read.

The following Resolution was then moved by the President, and seconded by Mr George Neilson, LL.D. :—

RESOLUTION.

Resolved that the Agreement which has been entered into between The Institution of Engineers and Shipbuilders in Scotland and The Royal Philosophical Society of Glasgow, dated the 2nd and 4th October, 1905, now submitted to the meeting and for the purpose of identification docquetted by the Chairman thereof be and the same is hereby adopted and confirmed : And that the Council be and they are hereby authorised to purchase the interest of the said Institution in the property 207 Bath Street, Glasgow, on the terms mentioned in the said Agreement, with any modifications in detail of which the Council may approve, and to take all necessary steps for completing the purchase and granting a lease to the said Institution as stipulated in said Agreement : And without prejudice to this generality, that the Council be and they are hereby authorised to apply the funds of the Society in carrying out the said purchase ; As also to borrow such sums of money not exceeding in all the sum of £4,000, upon such terms, for such period or periods and at such rate or rates of interest and generally on such terms and conditions as may seem to them to be proper to enable them to complete the said purchase ; And to convey in security of any such loans the whole or any part of the property from time to time belonging to the Society, and, if need be, from time to time to re-borrow or renew such loans.

Mr John F. Campbell moved, and Mr J. M'Kellar seconded, that the Resolution be not passed, and they were respectively heard in support of the Amendment.

Other Members having been heard and the discussion con-

cluded, the Chairman put the Resolution and the Amendment to the meeting, when there voted—

For the Resolution,	-	36
For the Amendment,	-	6

The Chairman then declared that the Resolution had been carried.

The Chairman further intimated that the Resolution would be brought forward for confirmation at a subsequent Extraordinary General Meeting of the Society.

15th November, 1905.

The Annual Business Meeting, for Session 1905-1906 of the Royal Philosophical Society of Glasgow, was held within the Rooms, 207 Bath Street, on the evening of Wednesday, 15th November, 1905, at 8 o'clock. The President, Dr David Murray, occupied the chair.

1. The Minute of previous Meeting, of date 1st November, 1905, having been printed in the Billet calling the Meeting, was held as read, was approved, and was thereupon signed by the Chairman.

2. The New Members elected at the previous Meeting were duly admitted.

3. The Annual Report by the Council (printed in the second Billet), was held as read, and was adopted on the motion of the Chairman.

4. The Hon. Treasurer's Abstracts of Accounts, signed by the Auditors, Mr C. D. Gairdner and Mr N. B. Gunn, were adopted on the motion of Dr George Neilson, and the thanks of the Meeting accorded to the Auditors.

5. The Hon. Librarian submitted the Annual Report of the Library Committee, and moved its adoption. The Report was adopted, and a vote of thanks passed to donors of books.

The business of the Ordinary Meeting was then proceeded with.

6. Mr Peter Macnair, Keeper of the Natural History Collections in the Glasgow Museums, and Secretary of the Geological Society of Glasgow, read a paper entitled, "On the Development of Foliation in the Highland Schists and its relationship to the Great Axial Lines of Folding," with numerous lantern illustrations.

EXPENDITURE—SESSION 1904-1905.

SESSION 1903-1904.

ORDINARY EXPENDITURE.	1904-1905.	1903-1904.
	£ s. d.	£ s. d.
ADMINISTRATION EXPENSES—		
Remuneration to Acting Secretary, - - £100 0 0		
Allowance for Treasurer's Clerks, - - 15 0 0		
Commission to Collectors, - - 11 13 7		
Telephone Rent, - - 5 5 0		
Stationery, - - 6 6 6		
Fire Insurance on Library, - - 6 10 0		
Postages, etc.—Per Secretaries, £10 4s. 1d. ;		
per Treasurer, £3 5s. 10d., - - 13 9 11		
	158 5 0	152 6 1
EXPENSES OF ROOMS, one half of £309 11s. 10d. ;		
less half of £67 14s. 6d. received for		
Lettings, - - - - -	120 18 8	122 6 7
LIBRARY—		
New Books and Periodicals, British and		
Foreign, - - - - -	83 3 7	146 5 3
PRINTING, ETC.—		
Printing <i>Proceedings</i> . Circulars, etc., - £215 19 1		
Postage and delivery of Circulars, - 30 19 1		
	246 18 2	157 10 7
SUBSCRIPTIONS TO SOCIETIES—		
Ray Society, 1905, - - - - -	1 1 0	3 3 0
EXPENSES OF SECTIONS PER SECRETARIES—		
Architectural, - - - - -	10 17 6	11 10 1
Mathematical and Physical, - - - - -	0 2 6	0 2 6
Economic Science, - - - - -	0 0 0	0 11 0
Geographical and Ethnological, - - - - -	0 0 0	0 0 0
Historical and Philological, - - - - -	1 15 6	0 9 5
Sanitary and Social Economy, - - - - -	0 3 4	0 7 10
EXCESS OF ORDINARY REVENUE over Ordinary		
Expenditure carried down, - - - - -	93 5 11	173 12 7
	<u>£716 11 2</u>	<u>768 4 11</u>
EXTRAORDINARY EXPENDITURE.		
LIBRARY CATALOGUE—		
Printing and Binding, - - - - - £126 16 0		
Honorarium to J. Robertson, - - 52 10 0		
	179 6 0	0 0 0
EXPENSES OF ROOMS—		
Half of £44 19s. 10d., for painting, - - - - -	0 0 0	22 9 11
SURPLUS CARRIED TO CAPITAL ACCOUNT, - - - - -	75 13 11	301 5 8
	<u>£254 19 11</u>	<u>323 15 7</u>

BALANCE SHEET, AS AT 30TH SEPTEMBER, 1905.

LIABILITIES.	INVESTMENTS—	ASSETS.
Capital at Beginning of Session, £4721 6 0	Bath Street Buildings and Furnishings—held jointly with the Institute of Engineers and Shipbuilders (Society's half as last year), - £3933 7 4	
Surplus from Revenue Account, 75 13 11	Caledonian Railway, £110 3 per cent. Preferred Converted Stock at cost, present value, £85 16s., 47 9 0	
Capital at close of Session (irrespective of Library), - £4796 19 11	Corporation of Glasgow—Deposit, - £850 0 0	
		Clydesdale Bank—Deposit Receipt, - 2 2 0
		£852 2 0
		35 18 5
		Less Due to Treasurer, 816 3 7
		<u>£4796 19 11</u>

GLASGOW, 6th November, 1905.—We, the Auditors appointed by the Society to examine the Treasurer's Accounts for the Session, 1904-1905, have examined the same, and have found them correct, the Balance due to the Treasurer being Thirty-Five Pounds Eighteen Shillings and Five Pence.

(Signed) C. D. GAIRDNER, C.A.
N. B. GUNN, F.F.A., F.I.A.

JNO. MANN, C.A., *Honorary Treasurer*.

GRAHAM MEDAL AND LECTURE FUND.

Dr.

ABSTRACT OF TREASURER'S ACCOUNT, SESSION 1904-1905

Cr.

CAPITAL AT 1ST NOVEMBER, 1904—	
£250 Glasgow and South-Western Railway Co. 4 Per Cent. Preference Stock in name of the Philosophical Society, in Trust, - - -	£250 0 0
Value of Die at H.M. Mint, - - -	18 18 0
Cash in Bank, - - -	268 18 0
	81 19 2
REVENUE—	
Dividend, March, 1905, less Tax, -	£4 15 0
" Sept., " - - -	4 15 0
Interest from Bank, - - -	0 18 8
	10 8 8
	£361 5 10

CAPITAL AT 30TH SEPTEMBER, 1905—	
Investment, <i>per contra</i> (present value, £288 15s.), - - -	£250 0 0
Die, - - -	18 18 0
	268 18 0
EXPENDITURE—	
Reporting on Competition Papers, - - -	2 2 0
BALANCE, BEING REVENUE—	
In Bank, on Deposit Receipt, - - -	90 5 10
	£361 5 10

GLASGOW, 6th November, 1905.—Examined and found correct.

JNO. MANN, C.A., *Honorary Treasurer*,
 (Signed) C. D. GAIRDNER, C.A.,
 N. B. GUNN, F.F.A., F.I.A.

Minutes of Session.

THE SCIENCE LECTURES ASSOCIATION FUND.

Dr. ABSTRACT OF TREASURER'S ACCOUNT—SESSION 1904-1905. *Cr.*

CAPITAL AT 1st NOVEMBER, 1905—		CAPITAL AT 30th SEPTEMBER, 1905—	
£200 Caledonian Railway Company		Investment, <i>per contra</i> (present	
4 Per Cent. Preference Stock, No. 1,		value, £234),	£244 4 8
in name of the Philosophical Society,		In Bank, on Deposit Receipt, . .	8 5 4
in Trust, cost,	£244 4 8		£252 10 0
On Deposit Receipt,	8 5 4		
	— — — —	BALANCE, BEING REVENUE—	
	£252 10 0	In Bank, on Deposit Receipt, . .	61 1 3
Cash in Bank (Revenue),	52 15 7		
REVENUE—			
Dividend, April 1905, less Tax, . .	£3 16 0		
„ Oct., „	3 16 0		
Interest from Bank,	0 13 8		
	— — — —		
	8 5 8		
	— — — —		
	£313 11 3		£313 11 3

GLASGOW, 6th November, 1905.—Examined and found correct.

JNO. MANN, C.A., Honorary Treasurer.

(Signed) C. D. GAIRDNER, C.A.
N. B. GUNN, F.F.A., F.I.A.

Mr Galloway, Mr Somerville, and Mr Napier took part in a discussion which followed.

Mr Macnair replied, and was accorded a vote of thanks on the motion of the Chairman.

29th November, 1905.

The Third Ordinary Meeting, for Session 1905-1906 of the Royal Philosophical Society of Glasgow, was held within the Rooms, 207 Bath Street, on the evening of Wednesday, 29th November, 1905, at 8 o'clock. The President, Dr David Murray, occupied the chair.

1. The Minute of previous Meeting, of date 15th November, 1905, having been printed in the Billet calling the Meeting, was held as read, was approved, and was thereupon signed by the Chairman.

2. The Rev. Andrew Miller, M.A., read a paper, entitled, "The Elberfeld System," being a communication from the Economic Science Section. A discussion followed in which part was taken by Mr John A. Todd, Mr Wm Buchanan, Miss Irwin, Mr Thomas Jones, Mr James R. Motion, Superintendent Douglas, Rev. Mr Watson, Mr Johannes N. Kiep, Mr John M'Kellar, and Dr Murray.

Mr Miller replied, and was accorded a vote of thanks on the motion of the President.

3. The Hon. Secretary announced that the following gentlemen had been duly elected to Membership of the Society :—

1. JAMES AIKEN, of Dalmoak, Writer, 201 West George Street. Recommended by Dr David Murray, Mr William Gillies, and Dr George Neilson.
2. Mr MARK BANNATYNE, Writer, 15 Windsor Terrace, West. Recommended by Dr David Murray, Mr William Gillies, and Mr John Clark.
3. Mr HENRY BROCK, Auchenheglish, Arden, Dumbartonshire. Recommended by Dr David Murray, Sir James Bell, Bart., and Dr Freeland Fergus.
4. Mr M. PEARCE CAMPBELL, 9 Lynedoch Crescent. Recommended by Dr David Murray, Dr Freeland Fergus, and Professor Peter Bennett.
5. Mr JOHN CARRICK, Stockbroker, 26 Renfield Street. Recommended by Mr John Young, Dr David Murray, and Mr John Mann, Jun.
6. Mr ARCHIBALD COLVILLE, The Moorings, Motherwell and Arngomery, Kippen. Recommended by Dr David Murray, Sir James Bell, Bart., and Dr George Neilson.

7. Mr DAVID COLVILLE, Jerviston House, Motherwell. Recommended by Dr David Murray, Sir James Bell, Bart., and Dr Oswald Fergus.
8. Mr JOHN CURRIE, 31 Westbourne Gardens. Recommended by Mr Wm. Kerr, Dr George Neilson, and Mr John Clark.
9. Mr DAVID DAVIDSON, 7 Bute Mansions, Hillhead. Recommended by Mr J. J. Spencer, Dr Freeland Fergus, and Professor Peter Bennett.
10. Mr DAVID ELLIS, D.Sc.,(Lond.), Ph.D.(Marburg), Lecturer in Botany, Technical College, Glasgow, 13 Princes Street, Pollokshields. Recommended by Professor Peter Bennett, Mr H. F. Stockdale, and Professor G. G. Henderson.
11. Mr H. F. GILLIES, Secretary G. & S.W. Railway, Thornly Park, Potterhill, Paisley. Recommended by Dr David Murray, Principal Angus M'Lean, and Dr Freeland Fergus.
12. Mr W. WEIR GRIEVE, 6 Bowmont Terrace, Hillhead. Recommended by Dr George Neilson, Dr David Murray, and Mr James MacLehose.
13. Mr ROBERT GUY, Writer, 120 West Regent Street. Recommended by Dr George Neilson, Mr J. T. T. Brown, and Mr R. D. Sandilands.
14. The Right Hon. LORD INVERCLYDE, 30 Jamaica Street. Recommended by Dr David Murray, Sir James Bell, Bart., and Dr Freeland Fergus.
15. Mr J. B. KIDSTON, Writer, 50 West Regent Street. Recommended by Dr David Murray, Mr William Gillies, and Dr Freeland Fergus.
16. Mr W. W. LACKIE, Electrical Engineer, 75 Waterloo Street. Recommended by Professor Magnus Maclean, Professor James Blyth, and Professor Peter Bennett.
17. Sir THOMAS J. LIPTON, Bart., K.C.V.O., Grand Officer of the Crown of Italy, Osidge, Southgate, Middlesex. Recommended by Dr David Murray, Sir James Bell, Bart., and Dr Freeland Fergus.
18. Mr JOHN M'CONNACHIE, 204 West George Street. Recommended by Dr David Murray, Mr William Gillies, and Dr George Neilson.
19. Mr WALTER MACKINTOSH, 19 Roxburgh Street, Kelvinside. Recommended by Dr George Neilson, Mr John Edwards, and Mr John Clark.
20. Mr B. B. MACGEORGE, 24 George Square. Recommended by Dr David Murray, Sir James Bell, Bart., and Mr John Clark.
21. Sir JOHN STIRLING MAXWELL, Pollok House, Pollokshaws. Recommended by Dr David Murray, Sir James Bell, Bart., and Dr Freeland Fergus.
22. Mr ALEXANDER MURDOCH, 557 Alexandra Parade. Recommended by Mr W. S. Curphey, Professor G. G. Henderson, and Dr Freeland Fergus.
23. Mr THOMAS RENNIE, Glasgow Art Gallery and Museum, Kelvingrove. Recommended by Dr George Neilson, Mr James D. Borthwick, and Mr J. J. Elliott.
24. Mr WILLIAM SLOAN, Dunara, Helensburgh. Recommended by Dr David Murray, Sir James Bell, Bart., and Professor Magnus Maclean.

25. Mr WILLIAM SPIERS, Jun., Invershiel, Lenzie. Recommended by Mr J. Craig Annan, Dr Freeland Fergus, and Mr James MacLehose,
 26. Mr ALEXANDER TENNANT, Bothwell Bank, Motherwell. Recommended by Colonel J. N. Smith, Professor Peter Bennett, and Dr George Neilson.
 27. Mr GEORGE JACK, 12 Melrose Gardens, Kelvinside. Recommended by Mr John M. Campbell, Mr John Clark, and Mr G. W. Alexander.
-

6th December, 1905.

An Extraordinary General Meeting of the Members of the Royal Philosophical Society of Glasgow, duly convened, was held in the Rooms of the Society, 207 Bath Street, on the 6th day of December, 1905, at 5 p.m. The chair was occupied by Mr George Neilson, LL.D., Vice-President.

It was agreed that the notice calling the Meeting should be held as read.

The following Resolution, passed at an Extraordinary Meeting of Members of the Society, on the 15th November, 1905, was submitted for confirmation as a Special Resolution on the motion of the Chairman. The motion having been seconded by Mr John A. Todd was put to the Meeting, when it was unanimously agreed to.

The Chairman thereupon declared that the Resolution had been duly carried.

RESOLUTION.

Resolved that the Agreement which has been entered into between The Institution of Engineers and Shipbuilders in Scotland and The Royal Philosophical Society of Glasgow, dated the 2nd and 4th October, 1905, now submitted to the meeting and for the purpose of identification docquetted by the Chairman thereof be and the same is hereby adopted and confirmed: And that the Council be and they are hereby authorised to purchase the interest of the said Institution in the property 207 Bath Street, Glasgow, on the terms mentioned in the said Agreement, with any modifications in detail of which the Council may approve, and to take all necessary steps for completing the purchase and granting a lease to the said Institution as stipulated in said Agreement: And without prejudice to this generality, that the Council be and they are hereby authorised to apply the funds of the Society in

carrying out the said purchase ; As also to borrow such sums of money not exceeding in all the sum of £4,000, upon such terms, for such period or periods and at such rate or rates of interest and generally on such terms and conditions as may seem to them to be proper to enable them to complete the said purchase ; And to convey in security of any such loans the whole or any part of the property from time to time belonging to the Society, and, if need be, from time to time to re-borrow or renew such loans.

13th December, 1905.

The Fourth Ordinary Meeting, for Session 1905-1906 of the Royal Philosophical Society of Glasgow, was held within the Rooms, 207 Bath Street, on the evening of Wednesday, 13th December, 1905, at 8 o'clock. The President, Dr David Murray, occupied the chair.

1. The Minute of previous Meeting, of date 29th November, 1905, having been printed in the Billet calling the Meeting, was held as read, was approved, and was thereupon signed by the Chairman.

2. The New Members elected at the previous Meeting were duly admitted.

3. Mr Edward French, Paisley Technical School, read notes on "A Simple Gas-Volumeter," and on "A Surface Tension Experiment," and exhibited the apparatus described.

A vote of thanks was accorded Mr French on the motion of Professor Gray.

4. Mr W. B. Inglis Pollock, M.D., read a paper on "The Eyesight of School Children," with lantern illustrations. A discussion followed, in which Dr Macmillan, Principal Williams, Dr Snodgrass, Dr Dyer, Dr Murray, and the Lecturer took part.

The thanks of the Meeting were accorded to Dr Pollock on the motion of the Chairman.

5. The Chairman announced that the following gentlemen had been duly elected to Membership of the Society :—

1. Mr JAMES GIBSON, M.A., Head Master, Woodside Public School. Recommended by Mr John Clark, Mr J. Vaughan, and Mr Wm Kerr.
2. Mr WM SMITH NICOL, F.F.A., 30 Renfield Street. Recommended by Sir James Bell, Bart., Dr David Murray, and Mr John Mann, Jun.

3. Mr THOMAS PRENTICE, 15 Eglinton Drive, Kelvinside. Recommended by Mr J. J. Spencer, Mr William Ewing, and Mr Walter Bergius.
 4. Mr JOHN A. FERGUSON, Kilmeny, Kirklee, Glasgow. Recommended by Mr William Kerr, Mr John Clark, and Mr John Mann, Jun.
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17th January, 1906.

The Fifth Ordinary Meeting, for Session 1905-1906 of the Royal Philosophical Society of Glasgow, was held within the Rooms, 207 Bath Street, on the evening of Wednesday, 17th January, 1906, at 8 o'clock. The President, Dr David Murray, occupied the chair.

1. The Minute of previous Meeting, of date 13th December, 1905, having been printed in the Billet calling the Meeting, was held as read, was approved, and was thereupon signed by the Chairman.

2. The New Members elected at the previous Meeting were duly admitted.

3. Sir William Ramsay, K.C.B., delivered a lecture, under the Science Lectures Trust, on "Some Facts and Theories connected with the Inactive Gases of the Atmosphere," illustrated by experiments and lantern slides.

A vote of thanks was accorded to the lecturer on the motion of Professor Andrew Gray, seconded by Mr H. A. Mavor.

31st January, 1906.

The Sixth Ordinary Meeting, for Session 1905-1906 of the Royal Philosophical Society of Glasgow, was held within the Rooms, 207 Bath Street, on the evening of Wednesday, 31st January, 1906, at 8 o'clock. In the absence of the President Dr George Neilson, Vice-President, occupied the chair.

1. The Minute of previous Meeting, of date 17th January, 1906, having been printed in the Billet calling the Meeting, was held as read, was approved, and was thereupon signed by the Chairman.

2. Bailie John Bruce Murray read a paper, entitled, "Social Reformation of Criminals," being a communication from the Social and Sanitary Section.

In the discussion which followed, part was taken by Professor Glaister, Rev. Mr Alexander, Colonel Smith Park, Bailie John

Ferguson, Bailie Edward Watson, Mr F. W. Moore, Chief Constable J. V. Stevenson, Bailie J. P. Maclay, Mr Landale, and Dr James Devon.

On the motion of the Chairman a vote of thanks was accorded to Bailie Bruce Murray, and further discussion on the paper adjourned till the Meeting on March 28th.

14th February, 1906.

The Seventh Ordinary Meeting, for Session 1905-1906 of the Royal Philosophical Society of Glasgow, was held within the Rooms, 207 Bath Street, on the evening of Wednesday, 14th February, 1906, at 8 o'clock. The President, Dr David Murray, occupied the chair.

1. The Minute of previous Meeting, of date 31st January, 1906, having been printed in the Billet calling the Meeting, was held as read, was approved, and was thereupon signed by the Chairman.

2. Mr James N. Miller, F.R.S.S.A., read a paper, illustrated by diagrams, on "Methods of Trisecting an Angle, of Dividing an Angle into Five equal Angles, and of Graduating the Circumference of a Circle into 360 equal Arcs." (Printed in the *Proceedings, R.S.E.*, 1901-1902.)

Professor Gray, Professor Bennett, and Mr Miller took part in the discussion which followed.

3. Mr G. E. Allan, D.Sc., read a paper on "The Magnetic Properties of some Minerals." The paper was illustrated by experiments and lantern slides.

Professor Gray and Dr Murray made appreciative and critical remarks on the paper.

4. Mr J. G. Gray, B.Sc., read a paper, entitled, "Some Notes on Heusler's Magnetic Alloys," illustrated by experiments and lantern slides.

A discussion followed, in which part was taken by Professor Bennett, Professor Gray, Mr Mavor, and Mr Gray.

On the motion of the Chairman, votes of thanks were accorded to Mr Miller, Dr Allan, and Mr Gray.

All three papers were communications from the Mathematical and Physical Section.

5. The Hon. Secretary announced that the following gentlemen had been duly elected to Membership of the Society :—

1. Mr WILLIAM J. ANDERSON, C A., Stockbroker, 149 West George Street. Recommended by Dr David Murray, Mr John Mann, Jun., and Dr Freeland Fergus.
 2. Mr H. E. GORDON, Aikenhead House, Cathcart. Recommended by Dr David Murray, Professor Magnus Maclean, and Mr John Mann, Jun.
 3. Mr W. B. NICOLSON, Scientific Instrument Maker, 54 Hill Street, Garnethill. Recommended by Professor Peter Bennett, Principal Angus M'Lean, and Dr Freeland Fergus.
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28th February, 1906.

The Eighth Ordinary Meeting, for Session 1905-1906 of the Royal Philosophical Society of Glasgow, was held within the Rooms, 207 Bath Street, on the evening of Wednesday, 28th February, 1906, at 8 o'clock. The President, Dr David Murray, occupied the chair.

1. The Minute of previous Meeting, of date 14th February, 1906, having been printed in the Billet calling the Meeting, was held as read, was approved, and was thereupon signed by the Chairman.

2. Professor G. G. Henderson, M.A., D.Sc., delivered a lecture, entitled, "With the British Association in South Africa." The lecture was copiously illustrated by lime-light views from photographs taken at the places visited by the Association.

Remarks appreciative of the lecture were made by Mr E. Maylard and the President, and on the motion of the latter, a vote of thanks was accorded to Dr Henderson.

3. The Hon. Secretary announced that the following gentlemen had been duly elected to Membership of the Society :—

1. The Right Hon. LORD OVERTOUN, D.L., Overtoun, Dumbarton. Recommended by Dr David Murray, Sir Samuel Chisholm, Bart., and Dr Freeland Fergus.
2. Mr ALEXANDER DAVIE, 219 St Vincent Street. Recommended by Mr William Fraser, Dr Freeland Fergus, and Professor Peter Bennett.

14th March, 1906.

The Ninth Ordinary Meeting, for Session 1905-1906 of the Royal Philosophical Society of Glasgow, was held within the Rooms, 207 Bath Street, on the evening of Wednesday, 14th March, 1906, at 8 o'clock. The President, Dr David Murray, occupied the chair.

1. The Minute of previous Meeting, of date 28th February, 1906, having been printed in the Billet calling the Meeting, was held as read, was approved, and was thereupon signed by the Chairman.

2. The adjourned discussion on Bailie John Bruce Murray's paper, "The Social Reformation of Criminals," was opened by Mr James R. Motion, who was followed by Sheriff Fyfe, Mr John Lindsay, Depute Town-Clérk, Mr A. Young, Police Court Assessor, Miss Irwin, Mr H. A. Mavor, Dr Carswell, and Mr John A. Todd.

It being now nine o'clock, the hour fixed for the reading of a paper by Mr John S. Samuel, the President stated that there was still a number of gentlemen on the list of speakers whose views on the subject he thought it was desirable to hear, and moved that the whole of the evening be devoted to the discussion of Bailie Bruce Murray's paper, and that it be remitted to the Secretaries to arrange for having Mr Samuel's paper on "Social Derelicts" read and discussed at a future Meeting.

The motion was adopted, and the discussion continued by Superintendent Douglas, Rev. Mr Alexander, Mr John M'Kellar, Dr George Neilson, Chief Constable Stevenson, Mr John S. Samuel, Mr John Mann, Jun., and Dr. David Murray.

Bailie Bruce Murray replied, and received the thanks of the Meeting on the motion of the Chairman.

28th March, 1906.

The Tenth Ordinary Meeting, for Session 1905-1906 of the Royal Philosophical Society of Glasgow, was held within the Rooms, 207 Bath Street, on the evening of Wednesday, 28th March, 1906, at 8 o'clock. In the absence of the President Mr H. A. Mavor, Vice-President, occupied the chair.

1. The Minute of previous Meeting, of date 14th March, 1906, having been printed in the Billet calling the Meeting, was held as read, was approved, and was thereupon signed by the Chairman.

2. Professor James Blyth, M.A., LL.D., delivered a lecture entitled, "The Experimental Bases of some Theories in Electricity," illustrated by numerous experiments. The lecture was a communication from the Mathematical and Physical Section.

On the motion of the Chairman, Professor Blyth was accorded a vote of thanks.

3. The Chairman intimated that the following gentlemen had been duly elected to Membership of the Society :—

1. Mr DANIEL WILKIE, Measurer and Valuator, 53 Bothwell Street. Recommended by Mr William Fraser, Dr Freeland Fergus, and Professor Peter Bennett.
 2. Mr ANDREW HENDERSON, Merchant, 15 Cadogan Street. Recommended by Mr John Edwards, Professor Archibald Barr, and Dr. Freeland Fergus.
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11th April, 1906.

The Eleventh Ordinary Meeting, for Session 1905-1906 of the Royal Philosophical Society of Glasgow, was held within the Rooms, 207 Bath Street, on the evening of Wednesday, 11th April, 1906, at 8 o'clock. The President, Dr David Murray, occupied the chair.

1. The Minute of previous Meeting, of date 28th March, 1906, having been printed in the Billet calling the Meeting, was held as read, was approved, and was thereupon signed by the Chairman.

2. Mr John F. Campbell and Mr James Neilson were nominated to audit the Hon. Secretary's Accounts at the end of the financial year.

3. Dr R. J. Lloyd, of Liverpool, delivered a lecture on the "Advantages of the Study and Acquisition of Esperanto."

On the motion of the Chairman, a vote of thanks was accorded to Dr Lloyd.

25th April, 1906.

The Twelfth Ordinary Meeting, for Session 1905-1906, of the Royal Philosophical Society of Glasgow, was held within the

Rooms, 207 Bath Street, on the evening of Wednesday, 25th April, 1906, at 8 o'clock. The President, Dr David Murray, occupied the chair.

1. The Minute of previous Meeting, of date 11th April, 1906, having been printed in the Billet calling the Meeting, was held as read, was approved, and was thereupon signed by the Chairman.

2. The Honorary Secretary intimated the death of Professor Langley, LL.D., Secretary of the Smithsonian Institution, and an Honorary Member of the Royal Philosophical Society.

3. The annual election of Office-bearers to fill the vacancies occurring by retirements took place, and the following appointments were unanimously made :—

- (i) Mr John Mann, Jun., elected Vice-President.
- (ii) Professor Dudley J. Medley, Dr William Snodgrass, Mr John A. Todd, and Sir John Stirling-Maxwell, Bart., elected Members of Council.
- (iii) Mr John Mann, Mr John Robertson, and Dr Freeland Fergus, re-elected Hon. Treasurer, Hon. Librarian, and Hon. Secretary respectively.
- (iv) Auditors, Mr John F. Campbell and Mr James Neilson.

4. Mr John S. Samuel, F.R.S.E., J.P., read a paper entitled, "Social Derelicts, or the contribution of the Army to Human Wastage," being a communication from the Sanitary and Social Economy Section.

In the discussion which followed part was taken by Dr Allan, Bailie Bruce Murray, Mr Hugh Reid, Dr George Neilson, Dr Freeland Fergus, Mr Wm. Buchanan, Mr W. D. Hamilton, Mr Roemmele, Mr Gibson, Mr Martin, and the President.

A vote of thanks was accorded to Mr Samuel, on the motion of the Chairman.

5. The Honorary Secretary intimated that Mr. WM. GAVIN PURDIE, 130 Cambridge Drive, had been elected a Member of the Society.

6. The foregoing Minute was read by the Hon. Secretary and approved by the Meeting, and the Chairman authorised to sign it when it should be engrossed in the Minute-book.

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OF THE

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SESSION 1905-1906.

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Romance of Modern Electricity. 1906.

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Catalogue of Greek Coins in the Hunterian Collection, University of Glasgow. Vol. 3. 4to. Glasgow, 1904.

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Financial History of Baltimore. By J. H. Hollander. Baltimore, 1899.

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Quarterly Journal of the Geological Society, Vol. 61, Part 4, and Vol. 62, Part 1.

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Geology of Mid-Argyll (Explanation of sheet 37). By J. B. Hill and others, with petrological notes. By J. J. H. Teal, and J. S. Flett, 1905.

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Esperanto language practically considered and described. By R. J. Lloyd. 12 mo. 1905.

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Transactions of the Institution, Vols. 28 to 37, 1895 and continued.

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Some early grammars and other school books in use in Scotland, more particularly those printed at or relating to Glasgow. 12 mo. Glasgow, 1905.

French translations of the Wealth of Nations. 12 mo. Glasgow, 1905.

Suggestions in reference to the Hunterian books and manuscripts. A memorandum for the University Court. Glasgow, 1905.

A glimpse of French school life in the sixteenth century. Edin., 1881.

Latin dictionary founded on Andrew's edition of Freund's latin dictionary. By Charlton T. Lewis, and Charles Short, Oxford, 1900.

- Greek-English lexicon, Compiled by H. G. Liddell, and Robert Scott. Oxford, 1901.
- From Mr J. Craig Annan—
International Exhibition, St. Louis, 1904. Official Catalogue of the British Section, Vol. 1.
- Report of His Majesty's Commissioners for the International Exhibition, St. Louis, 1904.
- From Mr Walter C. Bergius—
Transactions, Institution of Naval Architects, Vol. 47, Parts 1, 2.
Jahrbuch der Schiffbautechnischen Gesellschaft, Vol. 7. 4to. Berlin, 1906.
- From Volta Bureau—
Alexander M. Bell. By John Hitz. Washington, 1905. Pam.
- From Mr David Russell (Author)—
Reminiscences of my father. Dumfries, 1906. Pam.
- From Professor Ernst Haeckel (Author)—
Prinzipien der generellen Morphologie der Organismen. Berlin, 1906.
- From Dr John M'Vail—
County Council of Stirling. Annual Report of the Medical Officer for Health, 1905.
County Council of Dumbarton. Annual Report of the Medical Officer for Health, 1905.
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Illustrated Catalogue of pictures in the Glasgow Art Gallery and Museum, 1906.
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Bibliotheca Chemica: Catalogue of the Alchemical, Chemical, and Pharmaceutical Books in the collection of the late James Young of Kelly and Durris. By John Ferguson. 2 vols. 4to. Glasgow, 1906.
- From Dr. C. R. Macdonald—
County of Ayr—Annual Report of the Medical Officer for Health, 1905.
- From Mr Ludovic M'L. Mann, (Author)—
Prehistoric Renfrewshire—Note on the discovery of Bronze Age Burials with Urns at Newlands, Langside, Glasgow. With a Report on the Bones, by T. H. Bryce. 4to. Edinburgh. 1906. Pamphlet.
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Telegraphic determinations of Longitude made in the years 1888-1902. 4to. Edinburgh. 1906.
New reduction of Groombridge's Circumpolar Catalogue for the epoch 1810-0. By F. W. Dyson and W. G. Thackeray. 4to. Edinburgh. 1905.
- From Professor E. Haeckel (Author)—
Last words on Evolution. Translated by W. M'Cabe. 1906.
- From Dr. Thomas Muir—
Library Aids to Mathematical Research. Edinburgh. 1906. Pamphlet.

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Biographical Sketch of Alexander M. Bell. New York. 1898. Pamphlet.

Report of the Honourable John Eaton, U.S. Commissioner of Education for 1877, on Crime and Education. Pamphlet.

Joseph C. Gordon. By John Hitz. Washington. Pamphlet.

What has been done with one Deaf Child in his own Home. By Annie C. Reinhardt. 1905. Pamphlet.

How Helen Keller was Taught Speech. Washington. 1905. Pamphlet.

Seventh Report of the Home for the Training in Speech of Deaf Children before they are of School Age. 1904. Pamphlet.

Alexander Melville Bell. By John Hitz. Washington. Pamphlet.

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Manual of Medicine. 2nd Edition. 1906.

From Dr. Roger M'Neill—

Fifteenth Annual Report on the Health and Sanitary Condition of the County of Argyll for 1905.

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Infant Mortality. Bristol. 1906. Pamphlet.

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Thirty-sixth Annual Report on the Operations of the Sanitary Department of the City of Glasgow for 1905.

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Quarterly Journal of the Geological Society. Vol. 62, Parts 2-3.

From Mr James Paton—

Glasgow Art Gallery and Museum. Illustrated Catalogue of Sculpture. 1906.

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Some Meteorological Results of the Scottish National Antarctic Expedition. Edinburgh. 1906. Pamphlet.

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Fifteenth Annual Report upon the Health and Sanitary Condition of the County of Renfrew for 1905.

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Reports to the Evolution Committee. No. 3. Experiments undertaken by W. Bateson, Miss E. R. Saunders, and R. C. Punnett.

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Supplementary Essays on the Cause and Prevention of Dental Caries. 1906.

The Rôle of Modern Diatetics in the Causation of Disease. 1905.

From Dr. Hugh M'Laren—

Transactions of the Medico-Chirurgical Society of Glasgow. Vol. V. 1903-5. Glasgow. 1906.

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Area of Unknown Antarctic Regions compared with Australia, Unknown Arctic Regions, and British Isles. 1906. Pamphlet.

- Report on the Work of the Scottish Antarctic Expedition. Edinburgh. 1904. Pamphlet.
- From Dr John Brownlee (Author)—
Report of the City of Glasgow Fever and Smallpox Hospitals, Belvidere, for year ending May, 1905. Pamphlet.
- From Dr. James W. Allan (Author)—
Post-Graduate Demonstration in Ward I., Glasgow Royal Infirmary, May, 1906. Pamphlet.
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Catalogue of Books in the Library of the Institute of Accountants and Actuaries in Glasgow. 1906.
- From Glasgow Corporation—
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- From the Author—
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The Infinity of the Universe. By J. L. Adams. Sydney. 1906.

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- Wallace, Alfred Russell. My Life : a Record of Events and Opinions. 2 Vols. 1905.
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THE ROYAL PHILOSOPHICAL SOCIETY EXCHANGES WITH THE
FOLLOWING SOCIETIES, ETC. :—

AFRICA.

Cape Town—

- Cape of Good Hope Observatory. The Astronomer Royal.
South African Philosophical Society.

AFRICA—continued.

Johannesburg—

South African Association for the Advancement of Science.

Pretoria—

Transvaal Department of Agriculture.

AUSTRALIA.

Brisbane—

Royal Geographical Society of Australasia.

Melbourne—

Royal Observatory Library.

Royal Society of Victoria, Victoria Street.

Sydney—

Geological Survey, Department of Mines and Agriculture.

Royal Society of New South Wales, 5 Elizabeth Street, North.

Technological Museum.

Royal Anthropological Society of Australasia.

Australian Association for the Advancement of Science. The University.

Australian Museum.

University Library.

BELGIUM.

Brussels—

Académie Royale des Sciences.

Observatoire Royale.

Société Royale Malacologique de Belgique. 14 Rue des Sols.

Liège—

Société Royal des Sciences.

BRAZIL.

Rio de Janeiro—

Museu Nacional do Rio de Janeiro.

CANADA.

Guelph (Ont.)—

Entomological Society of Ontario.

Halifax—

Nova Scotian Institute of Science.

Hamilton (Ont.)—

Hamilton Association.

Montreal—

Canadian Society of Civil Engineers, 112 Mansfield Street.

Ottawa—

Geological Survey of Canada, Sussex Street.

Royal Society of Canada.

Quebec—

Literary and Historical Society of Quebec.

Regina—

Department of Agriculture, North-West Territories.

VOL. XXXVII.

S

- British Rainfall, 1902-03 04.
 Lilford, Lord. On Birds. Ed. by A. Trevor-Battye. 4to. 1903.
 Geological Magazine. Index. 1864-1903.
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 Society of Chemical Industry. Collective Index of the Journal. Vols. I.-XIV. 1882-95. 4to. 1899.
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 Woodward, Ellen S. Index to Geological Magazine. 1864-1903. 1905.
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AFRICA.

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 South African Philosophical Society.

AFRICA—*continued.*

Johannesburg—

South African Association for the Advancement of Science.

Pretoria—

Transvaal Department of Agriculture.

AUSTRALIA.

Brisbane—

Royal Geographical Society of Australasia.

Melbourne—

Royal Observatory Library.

Royal Society of Victoria, Victoria Street.

Sydney—

Geological Survey, Department of Mines and Agriculture.

Royal Society of New South Wales, 5 Elizabeth Street, North.

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Royal Anthropological Society of Australasia.

Australian Association for the Advancement of Science. The University.

Australian Museum.

University Library.

BELGIUM.

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Observatoire Royale.

Société Royale Malacologique de Belgique. 14 Rue des Sols.

Liège—

Société Royal des Sciences.

BRAZIL.

Rio de Janeiro—

Museu Nacional do Rio de Janeiro.

CANADA.

Guelph (Ont.)—

Entomological Society of Ontario.

Halifax—

Nova Scotian Institute of Science.

Hamilton (Ont.)—

Hamilton Association.

Montreal—

Canadian Society of Civil Engineers, 112 Mansfield Street.

Ottawa—

Geological Survey of Canada, Sussex Street.

Royal Society of Canada.

Quebec—

Literary and Historical Society of Quebec.

Regina—

Department of Agriculture, North-West Territories.

VOL. XXXVII.

S

CANADA—*continued.*

Toronto—

Canadian Institute, 58 Richmond Street, East.

Winnipeg—

Manitoba Historical and Scientific Society.

CHINA.

Hong Kong—

Hong Kong Observatory.

ENGLAND AND WALES.

Barnsley—

Midland Institute of Mining, Civil, and Mechanical Engineers, Elder Street.

Bath—

Bath Natural History and Antiquarian Field Club. Royal Literary Institution.

Birmingham—

Philosophical Society, Medical Institute, Edmund Street.

Bristol—

Bristol Naturalists' Society. Dr C. K. Rudge, Ashgrove House, 145 White Ladies' Road, Clifton.

Cambridge—

Philosophical Society, New Museum.

University Library. The Curator.

Cardiff—

Cardiff Naturalists' Society, Dr Griffith, 50 Newport Road.

South Wales Institute of Engineers, Park Place.

Falmouth—

Royal Cornwall Polytechnic Society.

Greenwich—

Royal Observatory. The Astronomer Royal.

Leicester—

Leicester Literary and Philosophical Society.

Liverpool—

Geological Society, Royal Institution, Colquitt Street.

Literary and Philosophical Society. Tate Librarian, University College.

Liverpool Engineering Society, Royal Institution, Colquitt Street.

London—

Anthropological Institute, 3 Hanover Square.

British Association for the Advancement of Science, Burlington House.

British Museum. The Superintendent, Copyright Office.

British Museum. Natural History Department, Cornwall Road.

Chemical Society, Burlington House.

Electrical Publishing Co., Ltd., 4 Southampton Row, Holborn, W.C.

Engineering. The Publisher, 35 Bedford Street, Strand.

Engineering Review Co., 104 High Holborn, W.C.

Institution of Civil Engineers, Great George Street, Westminster, S.W.

Institution of Mechanical Engineers, Storey's Gate, St. James' Park, Westminster.

Junior Institution of Engineers, 39 Victoria Street, Westminster, S.W.
Patent Office Library, 25 Southampton Buildings, Chancery Lane.
Pharmaceutical Society, 17 Bloomsbury Square.
Royal Geographical Society, 1 Saville Row, Burlington Gardens, W.
Royal Institute of British Architects, 9 Conduit Street, Hanover Square.
Royal Institution of Great Britain and Ireland, Albemarle Street, Piccadilly, W.

Royal Meteorological Society, 22 Great George Street, Westminster.
Royal Photographic Society, 66 Russell Square, W.
Royal Society, Burlington House.
Royal Statistical Society, 9 Adelphi Terrace, Strand.
Society of Arts, John Street, Adelphi.
Society of Biblical Archaeology, 37 Great Russell Street, Bloomsbury.
Society of Chemical Industry, Palace Chambers, 9 Bridge Street, Westminster.

Manchester—

Geographical Society, 16 St Mary's Parsonage.
Literary and Philosophical Society of Manchester, 36 George Street.

Middlesborough—

Cleveland Institution of Engineers, Corporation Road.

Newcastle-upon-Tyne—

North-East Coast Institution of Engineers and Shipbuilders, 4 St Nicholas Buildings.

North of England Institute of Mining and Mechanical Engineers, Neville Hall.

Oxford—

Bodleian Library.

Stratford (Essex)—

Essex Field Club. Essex Museum of Natural History, Romford Road.

Truro—

Royal Institution of Cornwall.

Watford—

Hertfordshire Natural History Society and Field Club, Upton House.

Welshpool—

Powys-Land Club. The Secretaries, Museum and Library, Salop Road.

FRANCE.

Bordeaux—

Société des Sciences Physiques et Naturelles de Bordeaux.

Marseilles—

Faculté des Sciences de Marseille.

Paris—

École Polytechnique. The Director.
Observatoire Météorologique Central de Montsouris.

Rennes—

Library of the University.

GERMANY.

Berlin—

Deutsche Chemische Gesellschaft.

Deutsche Kolonial Verein.

Königliche Preussische Akademie der Wissenschaften.

Giessen (Hesse)—

Oberhessische Gesellschaft für Natur-und-Heilkunde.

Griefswald (Prussia)—

Geographische Gesellschaft.

Halle (Prussia)—

Vereins für Erdkunde zu Halle.

Kaiserliche Leopoldino—Carolinische Deutsche Akademie der Naturforscher.

INDIA.

Calcutta—

Geological Survey of India.

IRELAND.

Belfast—

Belfast Naturalists' Field Club, Museum, College Square, North.

Natural History and Philosophical Society, Museum, College Square, North.

Dublin—

Royal Dublin Society, Leinster House.

Royal Irish Academy, 19 Dawson Street.

Trinity College Library.

ITALY.

Milan—

Reale Istituto di Lombardo di Scienze, Lettere, ed Arti.

JAPAN.

Kyōto—

Imperial University, College of Science and Engineering.

Tokio—

Imperial University of Tokio, Science College.

JAVA.

Batavia—

Royal Magnetical and Meteorological Observatory.

MEXICO.

Mexico—

Instituto Geologico de Mexico.

Observatorio Astronómico Nacional de Tacubaya.

Observatorio Meteorologico-Magnetico Central.

Sociedad Científica "Antonio Alzate."

MONACO.

Monaco—

Musée Océanographique.

NETHERLANDS.

Amsterdam—

Académie Royale des Sciences à Amsterdam.

Harlem—

Musée Teyler.

Société Hollandaise des Sciences à Harlem.

Leyden—

Kon. Nederlandsch Aardrijkskundig Genootschap.

NEW ZEALAND.

Wellington—

New Zealand Institute.

NORWAY.

Christiania—

Kongelige Norske Frederiks Universitet.

Videnskabs-Selskabet i Christiana.

ROUMANIA.

Bucharest—

Societatiî de Sciinte Fizice.

RUSSIA.

Kazan—

Imperial Kazan University.

St. Petersburg—

Académie Impériale des Sciences.

SCOTLAND.

Aberdeen—

Philosophical Society, 147 Union Street.

Alnwick—

Berwickshire Naturalists' Club, *per* George Bolaur.

Edinburgh—

'Advocates' Library.

Botanical Society of Edinburgh, Royal Botanic Garden.

Geological Society, 5 St Andrew Square.

Highland and Agricultural Society of Scotland, 3 George IV. Bridge.

Royal Physical Society, 18 George Street.

Royal Scottish Geographical Society, Queen Street.

Scottish Meteorological Society, 122 George Street.

Royal Scottish Society of Arts, 117 George Street.

Royal Society, The Mound, Princes Street.

Glasgow—

Archæological Society, 88 West Regent Street.

Baillie's Institution Free Library.

Faculty of Physicians and Surgeons of Glasgow, 242 St Vincent Street.

Geological Society, 207 Bath Street.

Glasgow University—

Glasgow and West of Scotland Technical College Library.

Institute of Accountants and Actuaries in Glasgow.

Institution of Engineers and Shipbuilders in Scotland, 207 Bath Street.

Mitchell Library, Miller Street.

Natural History Society of Glasgow, 207 Bath Street.

SCOTLAND—*continued.*

Glasgow—

- Stirling's Public Library, Miller Street.
- West of Scotland Iron and Steel Institute.

Hamilton—

- Mining Institute of Scotland.

SWEDEN.

Upsala—

- Royal University Library.

Stockholm—

- Kongliga Svenska Vetenskaps-Akademie.

TASMANIA.

Hobart—

- Royal Society of Tasmania.

UNITED STATES.

Albany—

- New York State Department of Health.
- New York State Library.

Austin (Texas)—

- Texas Academy of Science.

Baltimore—

- Johns Hopkins University.

Berkeley (Cal.)—

- University of California.

Boston—

- American Academy of Arts and Sciences.
- Boston Society of Natural History.
- Library of the City of Boston, Copley Square.

Buffalo—

- Buffalo Society of Natural Sciences.

Chicago—

- Western Society of Engineers.

Colorado Springs—

- Coburn Library, Colorado College.

Columbia (Mo.)—

- University of Missouri.

Davenport (Iowa)—

- Academy of Natural Sciences.

Denver—

- Colorado Scientific Society.

Des Moines (Iowa)—

- Iowa Geological Survey.

Indianapolis (Ind.)—

- Indiana Academy of Science.

Lawrence (Kansas)—

- Kansas University.

UNITED STATES—*continued.*

Madison (Wis.)—

Madison Geological and Natural History Society.
Washburn Observatory.

Mount Hamilton (Cal.)—

Lick Observatory.

Newhaven (Conn.)—

Connecticut Academy of Arts and Sciences.
Yale University.

New York—

American Geographical Society, 15 Eighty-first Street.
American Museum of Natural History, Seventy-seventh Street, and Central
Park West.
American Society of Civil Engineers, 220 West Fifty-seventh Street.
New York Public Library, 40 Lafayette Place.
New York Academy of Sciences Library, Seventy-Seventh Street, Central
Park, West.
School of Mines, Columbia College. The Associate Editor.

Philadelphia—

Academy of Natural Science of Philadelphia.
The Associated Alumni of the Central High School of Philadelphia.
American Pharmaceutical Association.
American Philosophical Society. The Hon. Secretaries, 104 South Fifth
Street.
Franklin Institute, 15 South Seventh Street.
Numismatic and Antiquarian Society of Philadelphia.
Wagner Free Institute of Science, corner of Seventeenth Street and
Montgomery Avenue.

Rochester (N. Y.)—

Rochester Academy of Science. Corresponding Secretary.

St. Louis—

Academy of Science of St. Louis.
Missouri Botanical Garden.

Salem—

American Association for the Advancement of Science.

San Francisco (California)—

California Academy of Sciences.

Topeka (Kansas)—

Kansas Academy of Science.

Washington—

Bureau of Education (Department of the Interior).
Bureau of Ethnology.
Smithsonian Institution.
United States Geological Survey.
United States National Museum (Department of the Interior).
United States Naval Observatory.
United States (Department of Agriculture).
Volta Bureau.

LIST OF PERIODICALS.

(Those received in exchange are indicated by an "a").

WEEKLY.

Academy.	English Mechanic.
Architect.	aIllustrated Official Journal of Abridgments of Patents.
Athenæum.	aJournal of the Society of Arts.
British Journal of Photography.	Journal of Gas Lighting.
Builder.	Lancet.
Building News.	La Nature.
Chemical News.	Nature.
Comptes Rendus.	Notes and Queries.
County and Municipal Record.	aPharmaceutical Journal.
aDeutsche Kolonialzeitung.	aPublishers' Circular.
Dingler's Polytechnisches Journal.	Scientific American and Supplement.
Electrical Review.	Zeitschrift für Angewandte Chemie.
Electrician.	
aEngineering.	

FORTNIGHTLY.

Annalen der Chemie (Liebig's).	Journal de Pharmacie et de Chimie.
aBerichte der Deutschen Chemischen Gesellschaft.	Journal für Praktische Chemie.

MONTHLY.

aAmerican Chemical Journal.	Antiquary.
American Journal of Science.	Beiblätter zu den Annalen der Physik.
Analyst.	Bulletin de la Société Chimique de Paris.
Annalen der Physik.	Bulletin de la Société Géologique de France.
Annales de Chimie et de Physique.	Bulletin de la Société Industrielle de Mulhouse.
Annales de l'Institut Pasteur.	Bulletin de la Société d'Encouragement pour l'Industrie Nationale.
Annales des Mines.	Bulletin of the American Mathematical Society.
Annales des Ponts et Chaussées.	aCanadian Entomologist.
Annales des Sciences Naturelles—Botanique.	
Annales des Sciences Naturelles—Zoologie.	
Annals and Magazine of Natural History.	

MONTHLY—*continued.*

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| <p><i>a</i>Engineering Review.
 <i>a</i>Electrical Magazine.
 <i>a</i>Geographical Journal.
 Geological Magazine.
 <i>a</i>Johns Hopkins University Circulars.
 Journal of Botany.
 <i>a</i>Journal of the Chemical Society.
 Journal of Education.
 <i>a</i>Journal of the Franklin Institute.
 <i>a</i>Journal of the Royal Photographic Society.
 <i>a</i>Journal of the Society of Chemical Industry.
 <i>a</i>Journal of the Western Society of Engineers.
 Library Association Record.
 Library World.
 London, Edinburgh, and Dublin Philosophical Magazine.
 Petersmanns Mittheilungen.</p> | <p>Polytechnic Bibliothek.
 <i>a</i>Proceedings of the Royal Society of London.
 <i>a</i>Proceedings of the Society of Biblical Archæology.
 Revue Universelle des Mines.
 <i>a</i>Royal Astronomical Society's Monthly Notices.
 Science Abstracts.
 <i>a</i>Science of Man.
 <i>a</i>Scottish Geographical Magazine.
 <i>a</i>Sitzungsberichte der Königlich Preussischen Akademie der Wissenschaften zu Berlin.
 <i>a</i>Tijdschrift van het Koninklijk Nederlandoeh Aardrijkskundig Genootschap.
 Zoologist.
 Zeitschrift für Analytische Chemie.</p> |
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QUARTERLY.

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| <p>Annals of Botany.
 Annals of Scottish Natural History.
 <i>a</i>Archives Néerlandaises des Sciences Exactes et Naturelles.
 <i>a</i>Bulletin of the American Geographical Society.
 <i>a</i>Bulletin of the Kansas University.
 Economic Journal.
 Englische Studien.
 Jahrbuch über die Fortschritte der Mathematik.
 Journal of Anatomy and Physiology.
 <i>a</i>Journal of the Anthropological Institute of Great Britain.
 <i>a</i>Journal of Manchester Geographical Society.
 <i>a</i>Journal of the Royal Institute of British Architects.
 Journal of the Royal Microscopical Society.
 <i>a</i>Journal of the Royal Statistical Society.
 <i>a</i>Journal of the Scottish Meteorological Society.</p> | <p><i>a</i>Memorias Y Revista de la Sociedad Científica "Antonio Alzate."
 Mind: a Quarterly Review of Psychology and Philosophy.
 <i>a</i>Proceedings of the American Philosophical Society.
 Quarterly Journal of Economics.
 Quarterly Journal of Geological Society.
 Quarterly Journal of Microscopical Science.
 <i>a</i>Quarterly Journal of Royal Meteorological Society.
 Quarterly Journal of Pure and Applied Mathematics.
 Reliquary and Illustrated Archæologist.
 Record of Technical and Secondary Education.
 Revue Historique.
 <i>a</i>School of Mines Quarterly.
 Scottish Historical Review.
 Scientific Roll.</p> |
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ANNUALLY.

British Journal Photographic Almanac.	Palæontographical Society's Publications.
Hazell's Annual.	Philosophical Transactions, Royal Society of London.
Jahres-Bericht Chemischen Technologie.	Ray Society's Publications.
Journal of the Royal Agricultural Society of England.	Report of the Board of Education.
Murray's English Dictionary.	Statesman's Year Book.
Journal de L'École Polytechnique.	Symons' British Rainfall.
	Wright's English Dialect Dictionary.

The LIBRARY and the READING-ROOM are open :—Winter, 9.30 a.m. till 8 p.m. (except Saturdays); Saturdays, till 2 p.m.

Summer (May till October, except during the holidays, from the 11th till 31st July), 9.30 a.m. till 5 p.m.; Saturdays, till 1 p.m.

LIST OF MEMBERS
OF THE
Royal Philosophical Society of Glasgow
FOR 1905-1906.

HONORARY MEMBERS.

(*Limited to Twenty.*)

WITH YEAR OF ELECTION.

FOREIGN.

Rudolph Albert von Kölliker, Würzburg.	-	-	-	-	-	-	-	-	1860
Professor Ernst Heinrich Hæckel, Jena.	-	-	-	-	-	-	-	-	1880
Professor Georg Quincke, Hauptstrasse 47, Friedrichsbau, Heidelberg.	-	-	-	-	-	-	-	-	1890
D. Ivanovitch Mendeléeff, 19 Zabalkansky, St Petersburg.	-	-	-	-	-	-	-	-	1904

AMERICAN AND COLONIAL.

5 Robert Lewis John Ellery, F.R.A.S., Victoria, Australia.	-	-	-	-	-	-	-	-	1874
Thomas Muir, M.A., LL.D., F.R.S.S., L. and E., Superintendent General of Education, Cape Colony.	-	-	-	-	-	-	-	-	1892

BRITISH.

Sir Joseph Dalton Hooker, C.B., G.C.S.I., M.D., D.C.L., LL.D., F.R.S., The Camp, Sunningdale.	-	-	-	-	-	-	-	-	1874
Rev. John Kerr, LL.D., F.R.S., Glasgow.	-	-	-	-	-	-	-	-	1885
The Right Hon. Lord Rayleigh, M.A., D.C.L., LL.D., F.R.S., F.R.A.S., F.R.S.G., Prof. of Nat. Philosophy in the Royal Institution, London, Terling pæce, Witham, Essex.	-	-	-	-	-	-	-	-	1890
10 The Right Hon. Lord Lister, O.M., LL.D., D.C.L., F.R.S., 12 Park crescent, Portland place, London, W.	-	-	-	-	-	-	-	-	1895
Sir Archibald Geikie, LL.D., D.Sc., F.R.S., F.R.S.E., F.G.S., Director-General of the Geological Survey of the United Kingdom, 10 Chester terrace, Regent's Park, London, N.W.	-	-	-	-	-	-	-	-	1895
The Right Hon. Lord Kelvin, O.M., G.C.V.O., LL.D., D.C.L., F.R.S., Largs. (<i>Ordinary Member, 1846 till 1896.</i>)	-	-	-	-	-	-	-	-	1896
Sir William T. Gairdner, K.C.B., M.D., LL.D., F.R.S., George sq., Edinburgh. (<i>Ordinary Member, 1863 till 1900.</i>)	-	-	-	-	-	-	-	-	1900
Professor Edward Albert Schäfer, LL.D., F.R.S., M.R.C.S., University of Edinburgh.	-	-	-	-	-	-	-	-	1902
15 Sir William Huggins, K.C.B., D.C.L. Oxon., LL.D. Camb, Pres. R.S., F.R.A.S., etc., 90 Upper Tulse-hill, London, S.W.	-	-	-	-	-	-	-	-	1904
Sir William Ramsay, K.C.B., LL.D., D.Sc., Ph.D., F.R.S., Professor of Chemistry, University College, London, 19 Chester Terrace, Regent's Park, London, N.W.	-	-	-	-	-	-	-	-	1904

CORRESPONDING MEMBERS.

WITH YEAR OF ELECTION.

A. S. Herschel, M.A., D.C.L., F.R.S., F.R.A.S., Hon. Professor of Experimental Physics in the University of Durham; Observatory House, Slough, Bucks.	1874
Thomas E. Thorpe, Ph.D., F.R.S., F.R.S.E., Principal of the Government Laboratories, Clement's Inn-passage, W.C.	1874
John Aitken, LL.D., F.R.S., F.R.S.E., Ardenlea, Falkirk.	1883
Alex. Buchan, M.A., LL.D., F.R.S.E., F.R.S., Secretary to the Scottish Meteorological Society, 122 George street, Edinburgh.	1883
5 James Dewar, M.A., F.R.S., F.R.S.E., M.R.I., Jacksonian Professor of Physics, University of Cambridge, and Professor of Chemistry in the Royal Institution of Great Britain, 1 Scroope terrace, Cambridge.	1883
Joseph W. Swan, M.A., D.Sc., F.I.C. F.C.S., M.I.Mech.E., Hon.M.I.E.E., F.R.S., 58 Holland Park, W.	1883
William Milne, M.A., B.Sc., F.R.S.E., Department of Public Education, Cradock, Cape Colony.	1894
Richard Lodge, M.A., Professor of History in Edinburgh University.	1899
Edmund J. Mills, D.Sc., LL.D., F.R.S., Emeritus Professor of Technical Chemistry, Glasgow and West of Scotland Technical College, 64 Twyford avenue, West Acton, London. W.	1901
10 Arthur Schuster, Ph.D., F.R.S., Professor of Physics, Victoria University, Manchester, Victoria park, Manchester.	1901
W. S. M'Cormick, M.A., LL.D., 2 St Andrew's square, Edinburgh.	1902
John George Bartholomew, F.R.S.E., F.R.G.S., Geographical Institute, Park road, Edinburgh.	1902
James Burgess, C.I.E., LL.D., F.R.S.E., Hon. A.R.I.B.A., F.R.G.S., 22 Seton place, Edinburgh.	1902
Francis Elgar, LL.D., F.R.S., F.R.S.E., 18 Cornwall Terrace, Regent's park, London, N.W.	1902
15 Frederick Emley, Literary and Philosophical Society of Newcastle-upon-Tyne.	1902
Professor Cargill G. Knott, D.Sc., F.R.S.E., 42 Upper Gray street, Edinburgh.	1902
Principal John Yule Mackay, M.D., LL.D., University College, Dundee.	1902
Professor John Millar Thomson, LL.D., F.R.S., F.I.C., F.C.S., King's College, and 9 Campden Hill Gardens, London, W.	1902
Professor Robert Wallace, F.R.S.E., F.L.S., F.C.S., University of Edinburgh.	1902

ORDINARY MEMBERS.

WITH YEAR OF ENTRY.

a Denotes Life Members.

Adam, Stephen, 168 Bath street.	1896	10 Alexander, D. M., 5 Derby crescent, Kelvin-side.	1887
aAdam, Thomas, F.S.I., 27 Union st.	1892	Alexander, G. W., M.A., 129 Bath street.	1893
Adams, John, M.B., 1 Queen's crescent, W.	1902	aAllan, Henry, 2 Park gardens.	1900
Adams, William, Makerstoun, Bearsden.	1891	aAllan, James A., 25 Bothwell street.	1904
5 Addison, W. H., Superintendent Mount Florida Deaf and Dumb Institution.	1895	Allan, James W., M.B., 18 India street.	1900
aAgar, Thomas F., Argentine Consul-General, 30 George square.	1896	15 Alston, J. Carfrae, 9 Lorraine gardens.	1887
Aiken, James, of Dalmoak, 201 West George street.	1905	Anderson, Alexander, 157 Trongate.	1869
Aikman, W. G., 12 Kingsborough gardens, Kelvin-side.	1899	aAnderson, David H., Atlantic Mills, Bridgeton.	1904
Aiton, Alexander Hamilton, 190 West George street.	1902	Anderson, James, 4 Kingsborough gardens.	1900
		Anderson, James, 168 George street.	1890

- 20 Anderson, James Scott, Bardowie Castle, Milngavie. 1902
 Anderson, James Spencer, 81 Great Clyde street. 1901
 Anderson, John, 142 West Nile st. 1884
 Anderson, J. B. Mackenzie, M.B., 8 Buckingham terrace, Hillhead. 1895
 Anderson, R. T. R., 42 Roselea drive. 1889
 25 Anderson, Robert, 76 Bath street. 1896
 Anderson, Robert, Eastwoodhill, Giffnock. 1900
 aAnderson, Robert Locke, 233 St Vincent street. 1901
 aAnderson, Sir T. M'Call, M.D., Professor of Practice of Medicine in the University of Glasgow, 9 The College. 1873
 Anderson, Wm, 12 Princes square. 1900
 30aAnderson, William, 133 Wellington street. 1890
 Anderson, W. F. G., 47 Union st. 1878
 Anderson, William, J., C.A., 149 West George street. 1906
 Andrew, Grant, 12 Woodside ter. 1900
 aAndrew, James, 160 West George street. 1900
 35 Angus, Robert, Lugar, Ayrshire, N.B. 1901
 aAnnan, J. Craig, 518 Sauchiehall street. 1888
 Annandale, Charles, M.A., LL.D., 35 Queen Mary avenue. 1888
 Arend, Waldemar, 1 Queensborough gardens. 1904
 Arneil, Allan, Stewarton drive, Cambuslang. 1901
 40aArnot, J. L., 204 Bath street. 1890
 Arrol, Theodore A., Torwood Hill, Row, Dumbartonshire. 1902
 Arrol, Wm. A., Torwoodhill, Row. 1869
 aArrol, Sir William, LL.D., Seafield, Ayr. 1900
 aArthur, Andrew, 78 Queen street. 1902
 45aArthur, James, 78 Queen street. 1900
 Arthur, Sir Matthew, Bart., 78 Queen street. 1900
 Arthur, Thomas G., Carrick house, Ayr. 1900
 Bain, Andrew, 17 Athole gardens. 1890
 Baird, Allan F., 192 St. Vincent street. 1904
 50aBaird, J. G. A., M.P., Wellwood, Muirkirk. 1892
 aBalfour, Alexander, Kelvindare, Kelvinside. 1900
 Ballantine, George, jun., 100 Union street. 1897
 Ballantyne, John H., 212 Bath street. 1904
 Bannatyne, Mark, 15 Windsor terrace, West. 1905
 55 Barbour, Wm, M.B., C.M., 3 Edelweiss terrace, Partick. 1900
 Barclay, A. J. Gunion, M.A., F.R.S.E., High School. 1893
 Barclay, A. P., 133 St Vincent street. 1890
 Barclay, George, 8 Windsor circus. 1891
 Barclay, James, 16 Roxburgh street, Kelvinside. 1871
 60 Barman, Harry D.D., 21 University gardens. 1904
 Barnet, John, 73 Robertson street. 1901
 aBarr, Archibald, D.Sc., Professor of Civil Engineering and Mechanics in the University of Glasgow, Royston, Downhill. 1898
 aBarr, James, C.E., I M., F.S.I., 221 West George street. 1883
 Barr, Patrick, 51 Bath street. 1902
 65 Barr, Thos, M.D., F.F.P.S.G., 13 Woodside place, W. 1879
 Barrett, Francis Thornton, Mitchell Library. 1880
 Bauermeister, F., 49 Gordon street. 1901
 Baxter, John, I.M., 243 St Vincent street. 1901
 Baxter, W. R., 36 Sutherland terrace. 1900
 70 Beardmore, W., Parkhead Forge. 1901
 Beatson, George T., B.A. (Cantab.), M.D., 7 Woodside crescent. 1881
 Beaumont, Frank, B.A. (Lond.), 19 Grantly gardens, Shawlands. 1904
 Becker, L., Ph.D., Professor of Astronomy in the University of Glasgow, The Observatory. 1895
 Beckett, Charles E., M.A., LL.B., 163 St Vincent street. 1903
 75 Beckett, William, M.A., 225 West George street. 1900
 Beedle, Peter D. Ridge, 166 Buchanan street. 1902
 Begg, Wm, 636 Springfield road. 1883
 Beilby, George T., F.R.S., 11 University gardens, Hillhead. 1895
 Bell, George, architect, 212 St Vincent street. 1900
 80aBell, Henry, Mynthurst, Reigate, Surrey. 1876
 Bell, Sir James, Bart, 135 Buchanan street. 1877
 aBell, James T., Woodbine, Blairmore, Argyleshire. 1896
 aBell, John J., Woodbine, Blairmore, Argyleshire. 1896
 aBennett, Professor Peter, Secretary, 207 Bath street. 1900
 85 Bennett, Robert J., Savoy park, Ayr. 1883
 Bergius, Walter, C.E., 77 Queen street. 1897
 aBiggart, Thomas, 105 West George street. 1900
 aBilsland, William, 28 Park circus. 1888

- Binnie, Thomas, Junr., M.A., 3 Park Gate. 1903
- 90a Birkmyre, John, Broadstone, Port-Glasgow. 1900
- a Bishop, A. Henderson, Burncroft, Thorntonhall. 1896
- Black, J. Albert, Lagarie, Row. 1869
- Black, Malcolm, M.D., 5 Canning place. 1880
- a Black, William Dunn, J.P., Auchentoshan, Dalmuir. 1901
- 95a Blackie, J. Alexander, 17 Stanhope street. 1881
- a Blackie, J. Robertson, North Bank, Dowanhill. 1881
- a Blackie, Walter W., B.Sc., The Hill House, Helensburgh. 1886
- Blackwood, Matthew, Ardmore, Port-Glasgow. 1901
- Blair, Matthew, Moorings, Thornly Park, Paisley. 1887
- 100 Blair, William, 24 St Vincent place. 1902
- Bles, Edward J., B.A.(Cantab.), B.Sc.(Lond. and Vict.) Natural History Department, University of Glasgow. 1905
- a Blyth, Robert, Balvonie, Skelmorlie. 1885
- a Blythswood, The Rt Hon. Lord, Renfrew, *Hon. Vice-President*. 1885
- Borthwick, James D., 46 Balshagray avenue, Partick. 1891
- 105a Boston, Alex. L., 12 Argyle arcade. 1902
- Bottomley, James T., M.A., D.Sc., F.R.S., F.R.S.E., F.C.S., 14 University gardens, Hillhead. 1880
- Bottomley, Wm, C.E., 15 University gardens. 1880
- Bower, F.O., D.Sc., M.A., F.R.S., F.L.S., Regius Professor of Botany in the University of Glasgow, 1 St John's terrace, Hillhead. 1885
- Bowers, John, *Depute Town Clerk*, City Chambers. 1904
- 110 Boyd, James, Boydston, Lenzie. 1905
- Boyd, John, Shettleston Iron-works, near Glasgow. 1873
- a Boyne, James, 106 West Nile street. 1901
- a Broadfoot, William R., Inchholme Works, Whiteinch. 1900
- Brock, Henry, Auchenhelish, Arden, Dumbartonshire. 1905
- 115 Brodie, William, B.L., 77 St Vincent street. 1902
- Bromhead, Horatio K., F.R.I.B.A., I.A., 18 Kirklee road, Kelvinside. 1901
- Brown, Alex., The Craigs, Carmunnock. 1896
- Brown, A. M., 22 West Nile street. 1900
- Brown, George Arbuckle, M.B., C.M., D.P.H.(Camb.), 180 Hyndland road, Partick. 1900
- 120a Brown, Hugh, 5 St John's terrace, Hillhead. 1887
- Brown, James, 76 St Vincent street. 1876
- Brown, John Armour, Moredun, Paisley. 1901
- Brown, J. T. T., Kessiebank, Cambuslang. 1902
- a Brown, Nicol Paton, 22 Belhaven ter. 1901
- 125 Brown, Richard, Writer, 166 St Vincent street. 1895
- Brown, Robert, 19 Jamaica street. 1882
- Brown, Thomas Mathieson, coal-master, Ardnith House, New Cumnock, Ayrshire. 1901
- Brown, Wm, F.S.A.A., F.S.I., 138 West Regent street. 1901
- a Brown, Wm Stevenson, 67 Washington street. 1886
- 130a Brown, William, 165 West George street. 1892
- Brown, Robert, B.Sc., 45 Washington street. 1893
- Brownlee, Jno., M.D., Glasgow Fever Hospital, Belvidere. 1902
- Brownlie, John Douglas, M.B., Ch.B., L.D.S., 10 Brandon place. 1901
- Brownlie, J. Rankin, L.D.S. (Eng.), 220 West George street. 1892
- 135 Bruce, Alex., Clyne House, Pollokshields. 1901
- Bruce, David, M.A., LL.B., 141 West George street. 1897
- Bryce, John, Assoc. M.Inst.C.E., Maxwell street, Partick. 1900
- a Buchanan, Andrew, Dunfillan, Helensburgh. 1902
- a Buchanan, A. W. G., Parkhill, Polmont, Stirlingshire. 1903
- 140 Buchanan, George Douglas, Silverrae, Giffnock. 1901
- Buchanan, Peter, 7 Garthland street. 1901
- Buchanan, Robert Macneil, M.B., C.M., F.F.P.S.G., 2 Northbank terrace, Kelvinside. 1900
- Buchanan, Walter, Clerkhill House, Dumbarton. 1901
- a Buchanan, Wm. Enderley, Bearsden. 1886
- 145 Burnet, John James, A.R.S.A., F.R.I.B.A., 70 University avenue. 1892
- Burns, J., M.D., 15 Fitzroy place, Sauchiehall street. 1864
- Burns, James, 2 Caird drive, Partick. 1905
- a Burrell, Wm, 54 George square. 1900
- Burton, William L., 6 Richmond crescent, Glasgow. 1899
- 150 Burr, Robert A., M.A., B.Sc., 26 Barnwell terrace, Govan. 1904
- Caird, Robert, LL.D., F.R.S.E., 56 Esplanade, Greenock. 1898
- Calder, Wm Ramsay, 102 Hope st. 1901

- aCaldwell, George B., Scotia Leather Works, Boden street. 1892
 Caldwell, James, 6 Newton place. 1900
 155 Cameron, Sir Hector C., M.D., Professor of Clinical Surgery, University of Glasgow, 200 Bath street. 1873
 aCampbell Arch., Springfield quay. 1895
 aCampbell, J. A., LL.D., M.P., Stracathro, Brechin. 1848
 Campbell, James Murdoch, 147 George street. 1901
 Campbell, John, 49 St Andrew's drive, Pollokshields. 1901
 160a Campbell, John Ferguson, 2 Holborn terrace, N. Kelvinside. 1892
 Campbell, John M., F.E.I.S., Kennedy St Public School, and 14 Royal crescent, Crosshill. 1900
 Campbell, John MacNaught, C.E., F.Z.S., F.R.S.G.S., 6 Franklin terrace, Dumbarton road. 1883
 Campbell, Malcolm, 18 Gordon street. 1894
 Campbell, M. Pearce, 9 Lynedoch crescent. 1905
 165 Campbell, Joseph Dawson, 142 West George street. 1903
 aCampbell, Thomas, Maryhill Iron works. 1894
 Campbell, The Right Reverend Archibald E., D.D., Bishop's House, Wood-side terrace. 1904
 Cant, James, Kilmeny, Ardrossan. 1901
 Carmichael, Neil, M.D., C.M., F.F.P.S.G., Invercarnel, 23 Nithsdale drive, Pollokshields. 1873
 170 Carson, D. S., C.A., J.P., St. Oswalds, Kilmacolm. 1905
 Carswell, John, F.F.P.S.G., L.R.C.P. Ed., 5 Royal cres., W. 1903
 Carver, Thomas, A. B., B.Sc., D.Sc., C.E., 8 Windsor quadrant, Kelvinside. 1890
 Carrick, John, 26 Renfield street. 1905
 Cayzer, Herbert Robin, Gartmore, Perthshire. 1901
 175a Cayzer, Sir Charles W., M.P., 109 Hope street. 1886
 Chalmers, A. K., M.D., D.P.H. (Camb.), 7 Buckingham terrace. 1892
 Chalmers, James, I.A., 93 Hope st. 1884
 Chalmers, P. MacGregor, I.A., F.S.A.Scot., 95 Bath street. 1891
 aChisholm, Sir Samuel, Bart., LL.D., 20 Belhaven terrace. 1890
 180 Christie, James Robertson, M.A., LL.B., 3 Gloucester place, Edinburgh. 1903
 aChristie, Henry W., 46 West George street. 1892
 Christie, John, Turkey-red Works, Alexandria, Dumbartonshire. 1868
 Christie, Wm. E., M.A., 47 Millbrae road, Langside. 1903
 aChristison, George, 13 Cambridge drive. 1897
 185 Chrystal, W. J., F.I.C., F.C.S., Shawfield Works, Rutherglen. 1882
 Clanachan, John, 4 Lloyd street, Dennistoun. 1900
 Clapperton, Alan E., 91 West Regent street. 1905
 Clark, John, Ph.D., F.I.C., F.C.S., 138 Bath street. 1870
 Clark, John, M.A., 2 Kelvingrove terrace. 1897
 190a Clarke, James Ferguson Wylie, M.A., F.R.C.S. Ed., 24 Buckingham terrace, Edinburgh. 1906
 Cleghorn, Alexander, 14 Hatfield drive, Kelvinside. 1904
 aCleland, John, M.D., LL.D., D.Sc., F.R.S., Professor of Anatomy in the University of Glasgow. 1884
 aCoats, Archibald, Woodside, Paisley. 1900
 Coats, John J., M.A., 27 Woodside place. 1900
 195a Coats, Sir Thomas Glen, Bart., M.P., Ferguslie, Park, Paisley. 1905
 aCochran, Robert, 7 Crown circus, Dowanhill. 1877
 Coghill, William C., 24 Douglas st. 1873
 Colquhoun, Walter, M.A., M.B., C.M., 7 Stanley street, W. 1900
 aColville, Archibald, The Moorings, Motherwell and Arngomery, Kippen. 1905
 200 Colville, James, M.A., D.Sc., 14 Newton place. 1885
 Colville, David, Jerviston House, Motherwell. 1905
 aCombe, James Russell, 10 Camphill avenue, Langside. 1895
 aConnell, Charles Broadfoot, Scotstoun Shipbuilding Yard, Whiteinch. 1900
 aConnell, James G., 44 St Enoch's square. 1900
 205 Cook, William, 77 St Vincent street. 1900
 Copland, Sir Wm R., M.Inst., C.E., F.S.I., 146 West Regent street. 1876
 Cooper, David, 18 Kingsborough gardens, Kelvinside. 1905
 Core, Wm, M.D., Stobhill Hospital, Springburn. 1891
 Cormack, J. D., B.Sc., Prof. of Mechanical Engineering, University College, Gower street, London, W.C. 1898
 210 Corrie, David, F.C.S., "Nobels," Polmont Station. 1902
 Costigane, J. T. Stewart, Limekilns House, East Kilbride. 1889

- Costigane, William, Clifton hall,
Albert drive, Pollokshields. 1890
- Coubrough, A. Sykes, Blanefield,
Stirlingshire. 1869
- Coulson, W. Arthur, 47 King street,
Mile-end. 1888
- 215 Couper, James, Craigforth House,
Stirling. 1862
- Couper, Sinclair, Moore Park Works,
Helen street, Govan. 1896
- Cowie, Archibald, 20 Blythswood
square. 1900
- Craig, T. A., C.A., 139 St Vincent
street. 1886
- aCrawford, R. C., 12 Derby crescent,
Kelvin-side. 1902
- 220 Cree, Thomas S., 21 Exchange sq. 1869
- Crichton, James, 201 Nithsdale road,
Pollokshields. 1892
- aCrookston, George B., 188 St Vin-
cent street. 1900
- Crosbie, Warren, B.L., 141 St. Vin-
cent street. 1904
- Cross, Alexander, M.P., 14 Wood-
lands terrace. 1887
- 225aCrum, Walter G., Dalnotter House,
Old Kilpatrick. 1895
- Crum, William G., Dalnotter House,
Old Kilpatrick. 1896
- Culbert, James, 12 Eildon Villas,
Mount Florida. 1902
- aCullen, Alexander, F. R. S. E.,
F.R.I.B.A., 3 Blythswood square. 1901
- aCurphey, Wm Salvador, 7 Derby
crescent, Kelvin-side. 1883
- 230 Currie, John, 31 Westbourne gardens. 1905
- Dalrymple, James D. G., F.S.A.,
Meiklewood, Stirling. 1902
- aDaly, James, 2 Prince's gardens. 1898
- aDalziel, T. Kennedy, M.B., C.M.,
196 Bath street. 1896
- Dansken, A. B., 109 St. Vincent
street. 1877
- 235 Darling, William, 178 St Vincent st. 1901
- Davidson, David, 7 Bute Mansions,
Hillhead. 1905
- Davie, Alexander, 219 St Vincent
street. 1906
- Dewar, David, 11 Havelock street,
off Byres road, Partick. 1903
- Dick, Thomas, 166 St Vincent street. 1901
- 240 Dickie, John S., 30 Renfield street. 1900
- aDixon, James S., Fairleigh, Both-
well. 1900
- Dixon, Walter, Derwent, Kelvin-side
gardens. 1893
- Dobbie, A. B., M.A., 24 West
Cumberland street. 1885
- aDobbie, Robert, Beechmount, Lar-
bert. 1900
- 245 Docherty, P. Alpine, L.R.C.P.,
L.R.C.S. Edin., etc., 526 Spring-
burn road. 1900
- aDonald, James Addie, 12 Waterloo
street. 1900
- Donald, John, 23 Queen Margaret
drive, N. Kelvin-side. 1872
- Donald, William, J. A., 16 Lilybank
gardens. 1877
- Douglas, Campbell, I.A., F.R.I.B.A.,
266 St Vincent street. 1870
- 250 Douglas, William M., 155 North
street. 1903
- Downie, J. Walker, M.B., C.M., 4
Woodside crescent. 1901
- Downie, Robert, jun., Carntyne Dye-
works, Parkhead. 1872
- Downie, Thomas, Hyde-park
Foundry. 1886
- aDreghorn, David, Greenwood, Pollok-
shields. 1896
- 255aDuncan, Eben., M.D., C.M.,
F.F.P.S.G., Queen's Park house,
Langside road, Hon. Vice-Presi-
dent. 1873
- Duncan, Hugh, M.A., LL.B., 54
West Nile street. 1895
- Duncan, J. A., Aston, Bridge of
Allan. 1896
- aDuncan, Robert, Whitefield Works,
Govan. 1890
- Dunlop, David John, Inch Works,
Port-Glasgow, and 198 Bath street. 1900
- 260 Dunlop, John, F.E.I.S., headmaster,
Quarry Brae Public School, Park-
head. 1900
- Dunlop, John, M.D., 1 Somerset
place. 1900
- aDunlop, Nathaniel, 25 Bothwell st. 1870
- aDunlop, Thomas, 70 Wellington
street. 1902
- Dunn, Hugh Shaw, Earlston Villa,
Caprington, Kilmarnock. 1901
- 265 Dunn, Robert Hunter, 4 Crown
terrace, Dowanhill. 1878
- Dyer, Henry, M.A., D.Sc., C.E., 8
Highburgh terrace, Dowanhill. 1883
- aEdington, George Henry, M.D.,
M.R.C.S. (Eng.), F.F.P.S.G., 20
Woodside place. 1896
- Edmiston, John C., M.D., F.F.P.S.G.,
24 Wilton gardens. 1901
- aEdwards, John, 4 Great Western
terrace, west. 1883
- 270 Elliott, Joseph J., City Chambers. 1901
- Ellis, David, D.Sc. (Lond.), Ph.D.
(Marburg), Lecturer in Botany,
Technical College, Glasgow, 13
Princes street, Pollokshields. 1905
- Erskine, Jas. M.A., M.B., L.F.P.S.G.,
351 Bath street. 1886

- Ewan, Thomas, M.Sc., Ph.D., 57 Montgomery street, Kirklee, Glasgow. 1901
- Ewing, James C., 14 Woodlands road. 1902
- 275a Ewing, Wm, 45 Renfield street. 1883
- aFaill, John, 7 Winton drive, Kelvinside. 1901
- Fairweather, Wallace, C.E., 62 St. Vincent street. 1880
- Falconer, Patrick, 13 Sutherland street, Hillhead. 1876
- Falconer, Thos, 50 Kelvingrove street. 1880
- 280a Farquhar, Jas T., 47 Hope street. 1901
- Farquhar, Wm R., St Malo, Kilmalcolm. 1892
- Farrelly, John, 25 Elmbank cres. 1901
- Fawsitt, Charles A., 9 Foremount terrace, Partick. 1879
- aFergus, Freeland, M.D., F.R.S.E., F.F.P.S.G., *Hon. Secy.*, 22 Blythswood sq. 1887
- 285 Fergus, James, 58 York street. 1901
- aFergus, Oswald, D.D.S., L.D.S., 12 Clairmont gardens. 1896
- Ferguson, Alexr., 164 Howard st. 1901
- Ferguson, David, Glenholm, Port-Glasgow. 1901
- Ferguson, Fergus, 20 Royal terrace, West. 1900
- 290 Ferguson, George, 130 Bishop street, Port Dundas. 1904
- Ferguson, James, Inglenek, Cathcart. 1897
- aFerguson, John, M.A., LL.D., F.R.S.E., Professor of Chemistry, University of Glasgow, *Hon. Vice-President*. 1869
- Ferguson, John A., Kilmeny, Kirklee, Glasgow. 1905
- Ferguson, John Forbes, 166 St Vincent street. 1895
- 295 Findlay, Joseph, Clairmont, Winton drive, Kelvinside. 1873
- Finlayson, James, M.D., LL.D., 2 Woodside place. 1873
- Fleming, Dr Robert H., 19 Newton street, Charing cross. 1901
- aFleming, E. Brown, Mambeg, Dumbartonshire. 1900
- aFleming, James, 136 Glebe street. 1880
- 300a Fleming, John, 241 St Vincent st. 1900
- Flower, Collingwood, Auchnacrioch, by Yoker, Renfrewshire. 1901
- aForrester, Henry, 105 West George street. 1900
- Foster, W. A., St Catherines, Newlands road, Langside. 1899
- Fotheringham, T. B., 52 Barrland street, Maxwell road. 1889
- 305a Fowler, John, 2 Grantly gardens, Shawlands. 1880
- Fraser, Melville, 31 St Vincent place. 1890
- aFraser, Thomas Smellie, F.S.I., 209 St Vincent street. 1900
- aFraser, Wm, F.S.I., 209 St Vincent street. 1900
- Freebairn, J. B., M.A., Napierhall Public School. 1900
- 310a French, Thomas, 1 Kelvinside ter. 1897
- Frew, Alex., C.E., Assoc. M. Inst. C.E., 216 West George street. 1876
- aFrew, William, Ph.D., c/o H. Whiteway, Esq., The Orchards, Whimpe, Devon. 1898
- Fryers, Arthur John, 22 Bath street, Largs. 1899
- Fullarton, Professor Robert, M.A., M.B., F.F.P.S.G., 272 Bath st. 1903
- 315a Fullerton, Robt., M.D., 24 Newton place. 1896
- Fulton, James, The Glen, Paisley. 1897
- Fulton, James, 33 Hamilton drive, Hillhead. 1902
- Fyfe, Alexander, 29 University avenue. 1897
- Fyfe, A. Peden, 124 St Vincent street. 1900
- 320 Fyfe, Henry B., 115 St Vincent street. 1892
- Fyfe, John W., F.S.I., 221 West George street. 1905
- aGairdner, C. D., C.A., 115 St Vincent street. 1886
- Galbraith, John Alexander, 28 Belhaven terrace. 1902
- Galbraith, Peter, 4 Beaumont Gate, Downhill. 1889
- 325 Galbraith, Walter M., 7 Holyrood crescent. 1893
- Galloway, T. Lindsay, C.E., 175 West George street. 1881
- Galt, Professor Hugh, B.Sc. M.B., C.M., F.F.P.S.G., D.P.H. (Camb.), 14 Berkeley terrace, W. 1900
- Gardner, Daniel, 36 Jamaica street. 1869
- Gardner, John, 146 Trongate. 1901
- 330 Gardner, John R., 33 Huntly gardens, Kelvinside. 1900
- aGarrett, Geo., Dunbeth lodge, Coatbridge. 1901
- aGarrow, James R., 6 Pollok road. 1890
- aGarraway, John, 694 Duke st. 1875
- Gemmill, James Fairlie, M.A., M.D., 21 Endsleigh gardens. 1901
- 335 Gemmill, William, 62 Bath street. 1903
- Gibson, Charles R., Lynton, Mansewood, by Pollokshaws. 1895
- Gibson, James, M.A., Head Master, Woodside Public School. 1905

- Gibson, William, 17 Wilton mansions. 1896
 Gillies, F. H., Thornly Park, Potterhill, Paisley. 1905
 340a Gillies, William, 23 University gardens. 1901
 Gillies, W. D., 17 Royal Exchange square. 1872
 Glaister, John, M.D., F.F.P.S.G., D.P.H. (Camb.), F.R.S.E., F.C.S., &c., Professor of Forensic Medicine and Public Health, University of Glasgow, 3 Newton place. 1879
 aGlaister, Joseph Newbigging, M.B., C.M., 5 Ronald street. 1900
 aGlen, Lawrence, 153 St Vincent street. 1900
 345a Glen, Robert, Carlston, Kelvinside. 1901
 Goldie, James, 52 St Enoch square. 1883
 Goodwin, Robert, C.E., 3 Lynedoch street. 1875
 Goold, James B., Bank of Scotland, Trongate. 1902
 Gordon, H. E., Aikenhead House, Cathcart. 1906
 350a Gordon, James, Sonebyres, 14 Aytoun road, Pollokshields. 1901
 aGourlay, Charles, B.Sc., A.R.I.B.A., Professor of Architecture, Glasgow Technical College, 30 Hamilton drive, Hillhead. 1900
 Gourlay, Robert, LL.D., 5 Marlborough terrace. 1904
 Gow, Leonard, 45 Renfield street. 1889
 Gow, Leonard, jun., 45 Renfield street. 1884
 355 Gow, Robert, 3 Victoria circus, Dowanhill gardens. 1860
 Graham, John Hatt Noble, Larbert House, Stirlingshire. 1900
 aGraham, Robert, 108 Eglinton st. 1888
 aGraham, William, B.L., 198 West George street. 1885
 aGraham, William, C.A., 6 Royal crescent, W. 1900
 360 Graham, Wm Edward Auld, 7 Royal Bank place. 1900
 Grant, Rev. James Bell, B.D., 113 Hillstreet, Garnethill, St. Stephen's Parish Church. 1903
 Graves, John William, Hydropathic, Kilmalcolm. 1901
 Gray, Albert A., M.D., 14 Newton terrace. 1903
 Gray, Andrew, 30 Bath street. 1889
 365 Gray, Andrew, LL.D., F.R.S., Professor of Natural Philosophy in Glasgow University, *Vice-President* 1899
 aGray, Thomas, D.Sc., Ph.D., F.I.C., F.C.S., Professor of Technical Chemistry, Glasgow Technical College. 1904
 aGregory, Professor J. W., D.Sc., F.R.S., Glasgow University. 1904
 Green, George, J.P., 40 Balshagray avenue, Partick. 1900
 Greer, Thomas Arthur, Fairfield works, Govan. 1901
 370 Greig, James R., Ravenswood, Crosshill. 1897
 Grier, R. P., 189 St Vincent street. 1901
 Grieve, W. Weir, 6 Bowmont terrace, Kelvinside. 1905
 Grove, John, jun., 199 St Vincent st. 1902
 Gumprecht, John, 6 Park quadrant. 1900
 375 Gunn, John, B.L., 144 Bath street. 1901
 Gunn, N. B., F.F.A., F.I.A., President of the Faculty of Actuaries in Scotland, 35 St Andrew square, Edinburgh. 1900
 Guthrie, David Wm., 166 Buchanan street. 1900
 Guthrie, John, 17 Whittinghame drive, Kelvinside. 1901
 Guy, Robert, 120 West Regent st. 1905
 380 Hall, Colonel Peter Wishart, V.D., Arisaig, Craigendoran, Helensburgh. 1901
 aHamilton, John, I.A., 212 St Vincent street. 1885
 Hanbidge, James E., 8 Balmoral crescent, Crosshill. 1897
 Harington-Stuart, R. E. S. (Colonel), Torrance, East Kilbride, N.B. 1900
 Harrington, John C., 14 Queen's Gate, Downhill. 1901
 385a Harrington, J. P., Broadfield, Port-Glasgow. 1900
 Harris, F. W., 32 Kyle Park, Uddington. 1900
 Harrison, John, J.P., 7 Granby ter. 1900
 aHart, Robert, 8 Greenlaw Avenue, Paisley. 1902
 Harvey, William Ure, Norman Hurst, Bearsden. 1896
 390 Harvie, William, 8 Bothwell terrace, Hillhead. 1888
 Hedley, H. A., 9 Derby crescent, Kelvinside. 1905
 aHenderson, Andrew, 15 Cadogan st. 1906
 aHenderson, A. P., 20 Newton place. 1880
 Henderson, Francis, 47 Union street. 1901
 395 Henderson, George G., M.A., D.Sc., F.I.C., F.C.S., Professor of Chemistry, Glasgow and West of Scotland Technical College, 204 George street. 1883
 Henderson, John, Reigate, Surrey. 1890
 aHenderson, Thomas, 1 Lancaster crescent, Kelvinside. 1900
 Henderson, Thomas Beath, M.D., 25 Lansdowne crescent. 1899

- aHenderson, William, 15 Cadogan street. 1873
 400 Hendry, Geo. Scott, 310 St. Vincent street. 1895
 Henry, R. W., 21 Oakfield terrace, W. 1875
 Higgins, Henry, jun., 248 West George street. 1878
 Hill, Thomas N., F.S.I., 180 Hope street. 1905
 Hinshelwood, James, M.A., M.D., 26 Woodside place. 1896
 405 Hinshelwood, Thomas, Kennyhill house, Dennistoun. 1903
 Hogg, Robert, 163 Nithsdale road, Pollokshields. 1865
 Holmes, Daniel T., B.A., Ingleholm, Bridge of Weir. 1898
 Honeyman, P. S., 12 South Park terrace. 1900
 aHope, James, Dean house, Lenzie. 1898
 410 Horne, Joseph, M.B., C.M., 45 Windsor terrace. 1900
 aHouldsworth, J. H., Rozelle, Ayr. 1900
 aHouldsworth, Wm Thos, Clerk in Holy Orders, 1 Mansfield street, Portland place, London, W. 1901
 Houstoun, Wm Henry, Hillcrest, Cambridge drive. 1895
 Howat, William, 37 Elliot street. 1885
 415aHunt, John, Milton of Campsie. 1881
 aHunter, Richard H., Glentyan, Kilbarchan, Renfrewshire. 1900
 Hunter, Robert, 72 Waterloo street. 1901
 Hunter, Walter K., M.D., 7 Woodside place. 1899
 aHunter, Wm S., 70 Robertson street. 1889
 420 Hutchison, John C., 8 Lansdowne crescent. 1900
 Hutchison, Joseph, Woodside, Netherburn, Lanarkshire. 1901
 Hutton, James, C.A., 203 West George street. 1897
 Hutton, W. K., M.A., M.B., Senior Demonstrator of Anatomy, The University. 1900
 aHyslop, William, of Bank, New Cumnock. 1901
 425 Inglis, John, LL.D., Pointhouse Shipyard. 1895
 aInglis, Malcolm, 48 St Andrew's square. 1900
 Inglis, R. A., Culrain, Bothwell, 1889
 Innes, Gilbert, 16 Kirklee road, Kelvinside. 1900
 Inverclyde, The Right Hon. Lord, 30 Jamaica street. 1905
 430aIrons, Joseph Jones, Summerlea, Kilcreggan. 1902
 Jack, George, 12 Melrose gardens, Kelvinside. 1905
 Jack, William Robert, M.D., 43 Lansdowne crescent. 1899
 aJack, William, M.A., LL.D., Professor of Mathematics in the University of Glasgow. 1881
 Jackson, Harold D., Easterhill, Helensburgh. 1902
 435 Jackson, Robert, 16 Dixon avenue, Crosshill. 1902
 Jackson, Thomas, C.A., 24 George square. 1900
 Jamieson, Andrew, F.R.S.E., M.Inst.C.E., M.Inst.E.E., etc., 16 Rosslyn terrace, Kelvinside. 1881
 Jenkins, James Graham, Airedale, Cambuslang. 1901
 Jenkins, Thomas, Woodlands, Crosshill. 1901
 440 Johnston, Alex., M.D. (Glasgow), D.P.H. (Camb.), Ruchill Hospital. 1900
 Johnston, David, 160 West George street. 1891
 Johnston, Michael, 19 Waterloo st. 1903
 Johnston, William G., Anchor Chemical Works. 1901
 Jones, Arthur L., 1027 Sauchiehall street. 1905
 445 Jubb, John, B.L., 190 West George street. 1902
 Kay, Arthur, J.P., Tregortha, Winton drive. 1904
 Kay, Cathcart, 77 St Vincent street. 1900
 Kay, Thomas, M.B., C.M., 5 Rosebery terrace. 1899
 Kean, James, 31 Scotia street, Garnethill. 1888
 450 Kedie, Robert, 11 Eglinton drive, Kelvinside. 1905
 aKelly, Alexander, 100 Hyde Park street. 1901
 Kelly, Hugh, M.D., Catrine Bank, Shields road, Pollokshields. 1898
 Kelly, J. H., J.P., Parkhead. 1900
 Kelly, James K., M.D., F.F.P.S.G., Park villa, Queen Mary avenue, Crosshill. 1889
 455 Kelly, John Davidson, M.A., Stanley house, Bridge-of-Allan. 1901
 Kemp, Wm (Alexander, Fergusson, & Co., Ltd), Ruchill, Maryhill. 1898
 aKennedy, Alexander, Kenmill House, Bothwell. 1902
 Kennedy, James, 43 Greendyke st. 1889
 Kennedy, Balie John, Airdrie. 1904
 460aKennedy, Moses Hunter, 217 West George street. 1901
 aKennedy, William, Partick, 13 Victoria crescent, Dowanhill. 1900

- aKer, Charles, M.A., C.A., 115 St Vincent street. 1885
 aKer, Wm, 1 Windsor terrace, Kelvin-side, West. 1874
 Kerr, Geo. Munro, 34 West George street. 1890
 465 Kerr, John G., M.A., LL.D., 15 India street. 1878
 Kerr, J. Graham, M.A., Professor of Zoology University of Glasgow, 15 Clarence dr., Hyndland. 1904
 Kerr, William, 260 West George street. 1902
 Kidston, Geo. J., Finlaystone, Lang-bank. 1900
 Kidston, J. B., 50 West Regent st. 1905
 470a Kidston, William H., 81 Great Clyde street. 1900
 aKiep, Johannes N., Imperia German Consul, 137 West George street. 1900
 aKing, Chas M., Antermony house, Milton of Campsie. 1900
 King, Sir James, Bart, LL.D., of Campsie, 115 Wellington street. 1855
 King, John, 17 Queen's crescent. 1895
 475 King, John C., 21 Newton place. 1898
 King, Professor L. A. L., 8 Ard-gowan terrace, Sandyford. 1905
 King, Robert, 115 Wellington st. 1905
 Kirk, Robert, M.D., Newton cot-tage, Partick. 1877
 Kirk, Rev. Edward Bruce, E.U. Manse, Barrhead. 1905
 480 Kirkpatrick, Alexander B., 88 St Vincent street. 1885
 Kirkwood, James, Carling lodge, Ibrox. 1890
 Knight, James, M.A., D.Sc., F.C.S., F.G.S., F.E.I.S., The Shielling, Uddingston. 1893
 aKnox, David J., 19 Renfield street. 1890
 Knox, John, Finnieston School. 1900
 485a Knox, John, 13 Montgomerie quad-rant, Kelvinside. 1902
 Lackie, W. W., 75 Waterloo street. 1905
 Laird, John, Royal Exchange Sale Rooms. 1879
 Lamb, David, 155 Hyndland road. 1896
 Lamberton, Alex., Lylestone, Hamil-ton drive, Pollokshields. 1900
 490 Lamberton, Andrew, Blairtummock, Easterhouse. 1904
 Lamberton, Hugh Alexander, Lyle-stone, Pollokshields. 1901
 aLamberton, Hugh, Surbition, 52 Dalziel drive, Pollokshields. 1900
 Lambie, Robert, Strathview, Lark-hall. 1901
 Lamond, Robert, M.A., LL.B., 163 West George street. 1984
 495 Lamont, Alexander, Kelvinhaugh Public School, 10 Ardgowan terrace, Sandyford. 1900
 Lang, William, Crosspark, Partick. 1865
 Lang, W. R., D.Sc., F.I.C., F.C.S., Professor of Chemistry in the Uni-versity of Toronto, Canada. 1899
 aLanglands, E. W., 113 West Regent street. 1902
 aLauder, James, F.R.S.L., Glasgow Athenæum. 1892
 500aLauder, John, 46 Gordon street. 1894
 Laughland, David, Linwood House, Linwood, Renfrewshire. 1901
 Laurie, Malcolm, B.A., D.Sc., F.L.S., Professor of Zoology, Clunaline, Lenzie. 1901
 Law, A. Bonar, M.P., Kintillo, Helensburgh. 1905
 Law, James H., Brandon House, Ibrox. 1901
 505 Law, John, R. K., 20 Ashton gardens, Dowanhill. 1896
 Lawrie, Sir Archibald C., LL.D., The Moss, Dungoyne, Stirling-shire. 1905
 aLawson, Thomas, Birchgrove, Pollok-shields. 1901
 Lee, William, M.A., F.E.I.S., 2 Tantallon terrace, Ibrox. 1901
 aLindsay, Archd M., M.A., 87 West Regent street. 1872
 510aLindsay, John, Conylea, Westbourne gardens, Kelvinside, 1902
 Lipton, Sir Thomas J., Bart., K.C.V.O., Grand Officer of the Crown of Italy, Osidge, Southgate, Middlesex. 1905
 Lobban, William, M.A., 48 Uni-versity avenue, Hillhead. 1905
 Lochhead, Dugald Ferguson, 41 Kelvinside gardens, Kelvinside. 1902
 Logan, James, Grammar School, Uddingston. 1902
 515 Lothian, A. Veitch, M.A., B.Sc., F.R.S.E., Lecturer, 25 Lilybank Gardens. 1891
 Love, James Kerr, M.D., C.M., 173 Bath Street. 1888
 Love, Wm., 28 Royal Exchange sq. 1901
 aLow, Isaac, 60 Weaver street. 1898
 aLumsden, Harry, M.A., LL.B., 105 West George street. 1900
 520 Lumsden, James, Arden House, Arden, Dumbartonshire. 1905
 Lundholm, C. O., Nobel's Ex-plosives Factory, Ardeer, Steven-ston. 1890
 M'Ara, Alexander, 65 Morrison st. 1888
 Macara, James, 19 Waterloo street. 1901

- M'Arly, Thomas, 29 W. George st. 1897
 525a M'Arthur, John S., 74 York street. 1890
 M'Ausland, William F., 51 Buchanan street. 1903
 Macbean, Ed, F.R.G.S., F.R.S.L., 31 Athole gardens. 1901
 M'Bryde, Peter, M.B., 18 Queen's crescent, W. 1900
 M'Calman, George, 1 India st., W. 1905
 530a M'Callum, Hugh, M.A., 7 Bute Mansions, Hillhead. 1902
 aM'Callum, Robert, junr., 69 Union street. 1891
 aM'Clelland, Andrew Simpson, C.A., 4 Crown gardens, Dowanhill. 1884
 M'Conville, John, M.D., 14 Parkgrove terrace. 1870
 M'Connachie, John, 204 West George street. 1905
 535 M'Cosh, Andrew K., Cairnhill, Airdrie. 1901
 aM'Cowan, David, jun., 9 Park circus place. 1898
 M'Cracken, James, 5 Bowmont terrace, Kelvinside. 1889
 M'Crae, John, 7 Kirklee gardens, Kelvinside. 1876
 M'Creath, James, M.E., 208 St Vincent street. 1874
 540 M'Culloch, Hugh, 154 West Regent street. 1880
 M'Donald, Alexander Beith, M.Inst. C.E., city engineer, City Chambers. 1901
 MacDonald, Charles, 55 Lochleven road, Langside. 1902
 aM'Donald, John, 72 Great Clyde st. 1896
 aMacdougall, Robert, F.S.A.A., F.S.I., 138 West Regent street. 1900
 545 M'Elligott, John, 4 Victoria drive, Mount Florida. 1901
 aM'Ewen, Robert, 11 Park terrace. 1900
 aMacfarlane, Walter, 22 Park circus. 1885
 M'Farlane, Wm, Edna Lodge, Rutherglen. 1888
 Macfee, John, M.I.E.E., 65 Renfield street. 1905
 550 Macgeorge, B. B., 24 George square. 1905
 aM'Gilvray, R. A., 129 West Regent street. 1880
 M'Gregor, A. N., M.D., 14 Woodside place. 1900
 MacGregor, D. O., M.D., Victoria Infirmary. 1904
 aMacgregor, R. D., 137 West George street. 1900
 555 Machell, Thomas, 1 Burnbank ter. 1886
 aMacindoe, Alex., 104 West George street. 1894
 Macintyre, John, M.B., C.M., 179 Bath street. 1895
 aM'Intyre, T. W., 21 Bothwell st. 1900
 M'Intyre, Wm, F.E.I.S., Dalmar-nock School, Glasgow. 1901
 560 Mackay, R. C., 82 West Regent st. 1903
 aM'Kechnie, D., 14 Candleriggs. 1900
 M'Kellar, John C., 45 West Nile st. 1896
 M'Kellar, J., 25 Kelvinside terrace. 1893
 Mackendrick, Alex., 518 Sauchiehall street. 1905
 565a M'Kendrick, John G., M.D., C.M., LL.D., F.R.S., F.R.S.E., F.R.C.P.E., Professor of Physiology in the University of Glasgow, 2 Buckingham terrace, *Hon. Vice-President.* 1877
 M'Kendrick, J. Souttar, M.D., F.R.S.E., 2 Buckingham terrace. 1900
 Mackenzie, John Alexander, M.B., C.M., 7 Sinclair drive, Langside. 1900
 Mackenzie, Robert, 176 St Vincent st. 1905
 aM'Kenzie, W. D., 43 Howard street. 1875
 570 M'Kie, John, M.B., C.M., 24 Hillside terrace. 1899
 Mackillop, Fred. G., M.A., LL.B., 208 St Vincent street. 1901
 aMackinlay, James Murray, The Lee, Merchiston, Edinburgh, 1886
 aMackinlay, J. T. C., 60 Montgomerie drive, Kelvinside. 1900
 aMackinlay, R. W., 52 Aytoun road, Pollokshields. 1900
 575 Mackintosh, Donald J., M.B., C.M., Western Infirmary, 1894
 Mackintosh, Walter, 19 Roxburgh street, Kelvinside. 1905
 aMackinnon, John, 63 Cliford street, Ibrox. 1904
 Mackinnon, William, C.A., 34 West George street. 1904
 MacLachlan, Dugald, B.L., 30 Renfield street. 1901
 580 MacLae, A. Crum, 192 St Vincent st. 1884
 M'Laren, Robert, Royal Bank, Garscube cross. 1898
 MacLaurin, Robert, 13 Claremont gardens, Milngavie. 1895
 M'Lay, James, C.A., 94 Hope street. 1900
 MacLay, W., Thornwood, Langside. 1893
 585 M'Lean, Angus, B.Sc. (Lond.), C.E., Principal, Technical College, Paisley. 1897
 Maclean, A. B., Craigpark Works, Flemington street, Springburn. 1899
 M'Lean, Charles R., L.R.C.P.E., L.R.P.S.G., 12 Annfield place, Dennistoun. 1900
 Maclean, Magnus, M.A., D.Sc., F.R.S.E., Professor of Electrical Engineering, Glasgow and West of Scotland Technical College, 51 Kersland terrace, Hillhead. 1885

- aMacLehose, James, M.A., 61 St Vincent street, 1882
 590 MacLellan, Lewis, 5 Bowmont gard. 1899
 aMacLellan, Peter, Glasgow Rubber Works, Maryhill. 1900
 aMacLellan, Wm. Walter, 3 Montague terrace, Kelvinside. 1900
 aMacleod, A., 54 Tytherton road, Tufnell park, London, N. 1893
 aMacleod, Frederick Larkins, 142 St. Vincent street. 1901
 595 Macleod, the Rev. Donald, B.A., D.D., 1 Woodlands terrace, 1900
 M'Michael, Thomas, M.A., B.Sc., 54 Windsor street. 1901
 M'Millan, A. Lewis, M.D., C.M., 1 Rosebery ter., Great Western rd. 1897
 M'Millan, Archibald, 5 Whittinghame gardens. 1899
 M'Millan, Robert, Methlan park, Dumbarton. 1901
 600a Macnab, James, Lilyburn, Milton of Campsie, Stirlingshire. 1901
 Macnair, John, 136 Claythorn street, and 1 Morris place, Monteith row. 1900
 Macnair, Matthew, 1 Morris place, Monteith row. 1901
 Macphail, Donald, M.D., Garturk cottage, Whifflet, Coatbridge. 1877
 Macpherson, Duncan, Rosemount School. 1900
 605 Macquaker, Thomas, 89 West Regent street. 1902
 M'Raith, James N., 4 Queen's square, Strathbungo. 1900
 M'Vail, D. C., M.B., Professor of Clinical Medicine, St Mungo's College, 3 St James' terrace, Hillhead. 1873
 M'Vail, John C., M.D., D.P.H. (Camb.), 20 Eton place, Hillhead. 1904
 aMacwbannell, Ninian, 58 West Regent street. 1898
 610 M'Whirter, W., 3 Albany street, Kelvinside. 1901
 Main, James, The Rowans, Bothwell. 1905
 Main, Robert B., Lyndhurst, 1 Winton drive, Kelvinside. 1885
 Malloch, A. M., Firhill, Garscube road. 1896
 aMann, James, 4 University gardens. 1900
 615a Mann, John, C.A., 142 St Vincent street, *Hon. Treasurer.* 1856
 aMann, John, jun., M.A., C.A., 142 St Vincent street 1885
 Mann, Ludovic MacLellan, 142 St Vincent street. 1897
 aMann, Robert M., 3 Montgomerie crescent. 1900
 Manwell, James, The Hut, 4 Albert drive, Pollokshields. 1876
 620 Marks, Samuel, 145 Great Eastern rd. 1884
 Marr, John, J.P., Dunjarg, Bella-houston, Govan. 1900
 Marr, Hamilton Clelland, M.D., Woodilee Asylum, Lenzie. 1899
 Marshall, James, Woodcroft, Crow road, Partick. 1900
 aMarshall, Robt., 97 Wellington street. 1900
 625 Martin, Jas F., 63 Brunswick st. 1895
 Martin, John, writer, 58 West Regent street. 1901
 Martin, Robert, 16 Ann street, Hillhead. 1897
 Martin, William, 63 Brunswick st. 1903
 Marwick, Sir J. D., LL.D., F.R.S.E., 19 Woodside terrace. 1878
 630 Mathie, George M., 15 Dunard road, Rutherglen. 1895
 Mathieson, J. H., 6 Park circus place. 1896
 aMathieson, T. O., 6 Park circus place. 1896
 Mavor, Henry A., *Vice-President*, 47 Broad street, Mile-end. 1887
 Mavor, Samuel, 37 Burnbank gard. 1890
 635a Maxwell, Sir John Stirling, Bart., Pollok House, Pollokshaws. 1905
 May, A. H., 15 Athole gardens. 1898
 Meares, H. P., 34 Ancaster drive, Jordanhill. 1902
 Mechan, Arthur, Scotstoun Iron-works. 1876
 Mechan, Henry, Scotstoun Iron Works, Scotstoun. 1879
 640 Medley, Dudley J., M.A., Professor of History in Glasgow University, 6 University gardens. 1901
 Mellanby, A. L., D.Sc., Professor of Motive Power Engineering, The Technical College, Glasgow. 1905
 Menzies, William Crawford, City Improvement Trust, 22 King st. 1895
 Millar, D. S., 144 St Vincent street. 1887
 Millar, James, 152 Parliamentary road. 1870
 645 Millar, Robert, 2 Rosslyn terrace, Kelvinside. 1903
 aMiller, Alexander Wingate, 79 West Nile street. 1900
 Miller, Alexander, jun., Dalmuir House, Dalmuir. 1899
 aMiller, Arch. Russell, Hillpark, Bothwell. 1884
 Miller, David S., 144 St. Vincent street. 1887
 650a Miller, George, Surrey House, Victoria Embankment, London, W.C. 1881
 Miller, Hugh, M.A., F.E.I.S., 2 Bogton Avenue, Cathcart. 1901
 aMiller, J. C., 40 West Nile street. 1900
 aMiller, Thomas Hodgson, Westcroft, Cleveland Walk, Bath. 1901

- aMirrlees, William J., 45 Scotland st. 1889
 655 Mitchell, Alexander Brown, Avon
 Bank house, Larkhall. 1901
 aMitchell, Alex. Moncrieff, 8 Kew
 terrace, Kelvinside. 1903
 Mitchell, Andrew, C.A., The Glas-
 gow District Subway Co., St
 Enoch square Station. 1896
 aMitchell, Andrew Acworth, 7 Huntly
 gardens. 1903
 aMitchell, George A., F.R.S.E., 5
 West Regent street. 1883
 660 Mitchell, Wm James, M.A., B.L.,
 48 West George street. 1897
 aMoffatt, Alexander, 23 Abercromby
 place, Edinburgh. 1874
 Mollison, James, 30 Balshagray aven.,
 Partick. 1889
 aMond, Robert Ludwig, B.A.
 (Cantab.), F.R.S.E., 20 Avenue
 rd., Regent's park, London, N.W. 1890
 aMonro, T. K., M.A., M.D.,
 F.F.P.S.G., Professor of Medicine
 in St Mungo's College, 12 Somerset
 place. 1897
 665aMonteith, Robert, Greenbank,
 Dowanhill gardens. 1885
 Moore, Alexander, C.A., Deanville,
 Bridge of Al'an. 1869
 Moore, Alexander George, M.A.,
 B.Sc., 13 Clairmont gardens. 1886
 aMoore, Robert Thomas, D.Sc., 13
 Claremont gardens. 1904
 Morrice, Jas A., 1 Prince's ter.,
 Dowanhill. 1883
 670aMorton, George, Horslethill road,
 Kelvinside. 1902
 Morton, James S., 118 Queen st. 1903
 Motion, James Russell, 266 George
 street. 1887
 Motion, Thomas Mason, 54 Grant
 street, W. 1897
 Muir, Alexander, 134 Nithsdale road,
 Strathbungo. 1883
 675aMuir, Allan, Ardmay, Newlands
 road, Langside. 1881
 Muir, James, D.Sc., M.A., Professor of
 Natural Philosophy, Technical
 College, Glasgow, 189 Renfrew st. 1904
 Muir, Robert, M.D., F.R.C.P.E.,
 Professor of Pathology in Glasgow
 University, 16 Victoria crescent,
 Dowanhill. 1899
 aMuirhead, Andrew Erskine, Cart
 Forge, Cathcart. 1873
 Muirhead, James, 2 Bowmont gar-
 dens, Kelvinside. 1887
 680aMuirhead, Robert F., M.A., D.Sc.,
 64 Great George street, Hillhead. 1879
 Munro, Alexander, M.B., C.M., 12
 Seton Terrace, Dennistoun. 1900
 Munro, Daniel, F.S.I., 10 Doune
 terrace, Kelvinside. 1867
 aMunro, Donald Mackay, 88 St
 Vincent street. 1901
 Munro, J. M. M., M.Inst. E.E.,
 M.Inst. C.E., F.R.S.E., 136 Both-
 well street. 1896
 685 Murdoch, Alexander, 557 Alexandra
 Parade. 1905
 Murdoch, George, 40 St Vincent
 place. 1894
 Murdoch, John, 208 West George st. 1901
 aMurdoch, Robert, 91 Maxwell road. 1880
 aMurray, A. S. 169 West George st. 1905
 690 Murray, Charles Robert, Woodbank,
 Partickhill. 1902
 aMurray, Daniel, 5 Wilton crescent. 1896
 aMurray, David, LL.D., 169 West
 George street, *President*. 1876
 Murray, John Bruce, 24 George sq. 1890
 Murray, R. A., C.A., 175 West
 George street. 1905
 695 Napier, Alex., M.D., F.F.P.S.G.,
 Rose Bink, Queen Mary avenue,
 Crosshill. 1886
 Napier, Robert T., 75 Bothwell
 street, Glasgow. 1899
 aNeilson, George, LL.D., Pitlochrie,
 11 Annfield terrace, Partick, *Vice-
 President*. 1897
 aNeilson, James, 116 Bishop street,
 Port-Dundas. 1896
 aNeilson, John, Mollance, Castle-
 Douglas. 1900
 700aNeilson, Walter, Ewenfield, Ayr. 1900
 Nelson, Alex., 63 North Frederick
 street. 1880
 aNelson, John E., 26 Queen street. 1900
 Nelson, Thos C., Craiglea, Dennis-
 town. 1900
 Ness, Jamer, M.A., LL.B., 216 West
 George street. 1904
 705 Ness, Professor R. Barclay, M.A.,
 M.B., 19 Woodside place. 1902
 aNewlands, Joseph F., 105 West
 George street. 1883
 Nicol, James Monro, 93 Cheapside
 street. 1901
 Nicol, William Smith, F.F.A., 30
 Renfield street. 1905
 Nicolson, W. B., 54 Hill street,
 Garnethill. 1906
 710aNicoll, Professor James H., M.B., 4
 Woodside place. 1897
 aNisbet, John, 112 Bath street. 1905
 Nisbet, Thomas, M.Inst. C.E., Master
 of Works, City Chambers. 1902
 Nish, Robert, 9 Claremont terrace. 1897
 Orr, George Smith, 139 St Vincent
 street. 1901

- 715 Orr, John, 101 Wellington street. 1921
 Orr, Robert, 79 West Nile street. 1890
 aOsborne, Hugh, 4 Kew terrace, Glasgow. 1899
 aOswald, Dr Landel Rose, Glasgow Royal Asylum. 1902
 Overtoun, The Right Hon. Lord, D.L., Overtoun, Dumbarton. 1906
- 720 Park, James, 51 Milburn street. 1877
 aPark, Colonel J. Smith, V.D., 20 Park terrace. 1900
 Park, Robert, M.D., 40 Grant st. 1894
 Parker, James H., B.L., C.A., 89 West Regent street. 1900
 aParker John Dunlop, C.E., 146 West Regent street. 1889
 725aParnie, William, 27 Union street. 1897
 Parry, Robert Henry, F.R.C.S.E., 25 Blythswood square. 1900
 aPaterson, Robert, C.A., J.P., 105 West George street. 1881
 Paterson, Wm., M.B., C.M. (Edin.) 43 Millbrae Road, Langside. 1902
 Paton, James, F.L.S., Glasgow Art Gallery and Museum, Kelvingrove. 1876
- 730 Patrick, Joseph, M.A., C.A., 203 West George street. 1893
 Patrick, Joseph, Royal Exchange buildings. 1900
 Patterson, T. L., F.C.S., Maybank, Finnart street, Greenock. 1873
 Petrie, John W., 4 Garrioch drive, Kelvingrove, N. 1900
 Pettigrew, Andrew H., 3 Claremont terrace. 1902
- 735aPicken, David Kennedy, B.A., Ashburne, Partickhill. 1903
 Pinkerton, Surgeon-Major-General, J., M.D., K.H.P., Queen's Park House, Langside. 1900
 aPirrie, Robert, 9 Buckingham ter. 1875
 Playfair, David James, 7 Victoria crescent, Dowanhill. 1901
 Pollock, A. Barr, M.B., C.M., 3 Belgrave terrace, Hillhead. 1897
- 740aPollock, R., M.B., C.M., F.F.P.S.G., Laurieston house, Pollokshields. 1883
 Prentice, Thomas, 15 Eglinton drive, Kelvingrove. 1905
 Procter, Robert, Claremont, Alloa. 1901
 Provand, A. D., 2 Whitehall court, London, S.W. 1888
- Raalte, Jacques Van, c/o M. Van Raalte, Esq., 22 Austen Friars, London, E.C. 1884
- 745aRalston, William Henry, 4 North Court, Royal Exchange. 1900
 Ramsey, Robert, 14 Park terrace. 1889
- aRamsey, Robert, junr., 14 Park ter. 1898
 Rankin, The Rev. W. M., B.D., clergyman, 8 Craigpark, Dennistoun. 1900
 Rankine, Adam, Rolandseck, Bridge of Weir. 1901
 750 Rankine, David, C.E., 238 West George street. 1875
 aReid, Andrew Thomson, 10 Woodside terrace. 1900
 Reid, David, 18 Cambridge street. 1887
 aReid, Hugh, Belmont, Springburn. 1880
 aReid, James A., Dean of Faculty of Procurators, 172 St Vincent street. 1904
 755 Reid, James, 15 Montgomerie crescent. 1886
 aReid, Joseph, 32 Newark drive, Pollokshields. 1901
 aReid, Nicholas M'Whirter, 7 Oakley terrace, Dennistoun. 1901
 Reid, Robert, C.A., 40 St Vincent pl. 1900
 Reid, Thos, M.D., LL.D., 11 Elm-bank street. 1869
 760 Reid, William, M.A., 61 Grant st. 1881
 aReid, Walter M. N., 10 Woodside terrace. 1904
 aReid, William L., M.D., 7 Royal crescent, West. 1882
 Renton, James Crawford, M.D., L.R.C.P. & S.Ed., 1 Woodside terrace. 1875
 aRennie, John, Wellcroft, Helensburgh. 1901
- 765 Rennie, Thomas, Glasgow Art Gallery and Museum, Kelvingrove. 1905
 aRenwick, Wm, Langgarth, Stirling. 1901
 Robb, George, carting superintendent, Caledonian Railway. 1901
 Robb, William, F.R.C.V.S., 6 Canning place, Stirling road. 1900
 aRobertson, William, 223 Sauchiehall street, Glasgow. 1899
- 770aRobertson, Henry Tod, Meadowbank, Airdrie. 1901
 Robertson, John, Endcliffe, Langside, *Hon. Librarian*. 1860
 Robertson, J. M'Gregor, M.A., M.B., C.M., 26 Buckingham ter., Hillhead. 1881
 Robertson, Mure, M.E., 4 Clairmont gardens. 1897
 aRobertson, Robert, B.Sc., M.Inst. C.E., M.I.E.E., etc., 154 West George street. 1900
- 775 Robertson, Robert H., Clyde bank, Rutherglen. 1888
 Robertson, Wm, 15 Gordon street. 1900
 Rodger, Anderson, Glenpark, Port-Glasgow. 1899
 Roemmele, C. H., 34 Kelvingrove gardens. 1900

- aRogers, John C., 204 Bath street. 1888
 780 Rose, Alexander, Richmond house,
 Dowanhill. 1879
 Rose, Hugh, 26 Eglinton drive. 1900
 aRoss, John Lochbrae House, Bears-
 den. 1885
 Ross, John, Munn, C.A., 117 Wel-
 lington street. 1894
 Ross, Russell James, manager, Park-
 head Steel Works, 7 Ashfield gar-
 dens, Jordanhill. 1901
 785 Rottenburg, Fritz, 55 West Regent
 street. 1905
 aRottenburg, Paul, LL.D., 55 West
 Regent street. 1872
 Rowan, James, 22 Woodside place. 1897
 Rowan, John, M.B., F.F.P.S.G., 10
 Woodside crescent. 1900
 Rowan, W. G., 234 West George
 street. 1881
 790aRowley, Thos, Campbell street,
 Govan. 1901
 Russell, James, c o Cluness, 25
 Woodside quadrant. 1904
 Russell, Robert, M.E., Coltness
 Iron Co., Ltd., Newmains,
 Lanarkshire. 1901

 Salmon, W. Forrest, F.R.I.B.A.,
 53 Bothwell street. 1870
 aSamuel, John Smith, F.R.S.E., J.P.,
 secretary to the Lord Provost of
 Glasgow, City Chambers. 1901
 795 Sandeman, B., Ferndean, Lenzie. 1900
 Sandilands, Robert Douglas, 4 Jane
 street, Blythswood square. 1902
 Sawers, William D., Assoc.I.C.,
 Athole Garden place. 1894
 Sayers, William Brooks, M.I.E.E.,
 189 St Vincent street. 1890
 Scott, Alexander, M.D., 12 Newton
 place. 1900
 800 Scott, Alex., 34 Lawrence street,
 Dowanhill. 1871
 aScott, D. M'Laren, The Grange,
 Bearsden. 1881
 Scott, John, 249 West George street. 1892
 aService, Edward, 92 St Vincent
 street. 1901
 Service, R. Gibson, 14 Royal Ex-
 change buildings. 1900
 805aService, William, 1 Queen's gate,
 Dowanhill. 1900
 Sexton, A. Humboldt, F.C.S.,
 F.I.C., F.R.S.E., Professor of
 Metallurgy, Glasgow and West of
 Scotland Technical College, 204
 George street. 1892
 Shand, F. J., 4 Bowmont gardens,
 Kelvinside. 1903
 aShanks, J. B., 46 Gordon street. 1900

 aShaw, A. M'Innes, Dunard, Syden-
 ham, Dowanhill. 1900
 810 Shaw, William, Ivy Lodge, Dullatur. 1900
 aShearer, William, 108 St Vincent
 street. 1901
 aSherriff, George, Carronvale, Larbert,
 Stirlingshire. 1900
 Shields, Daniel, 104 West George
 street. 1900
 Simons, Michael, 2 Kensington gate. 1880
 815aSimpson, J. C., M.D., 9 Marl-
 borough terrace, Kelvininside. 1896
 Sloan, Samuel, M.D., 5 Somerset
 place. 1905
 Sloan, William, Dunara, Helens-
 burgh. 1905
 Smart, William, M.A., LL.D., Pro-
 fessor of Political Economy, Uni-
 versity of Glasgow, Nunholm,
 Dowanhill. 1886
 Smellie, James, I.M., 112 Bath street. 1901
 820aSmith, Andrew, Miltonlea, Kilmal-
 colm. 1901
 Smith, Colonel J. N., V.D., Dykebar
 house, Hawkhead, Paisley. 1900
 Smith, D. Johnstone, C.A., 142 St
 Vincent street. 1888
 aSmith, David Baird, LL.B., 205
 St Vincent street. 1903
 aSmith, Fred. J., 40 St Vincent place. 1901
 825 Smith, George, 1 Annfield terrace,
 East Partick. 1901
 Smith, Hugh C., 55 Bath street. 1861
 aSmith, J. Guthrie, 205 St Vincent
 street. 1875
 aSmith, James Murray, 11 Bute
 gardens. 1901
 Smith, G. Comrie, 4 Camphill avenue,
 Langside. 1903
 830 Smith, Patrick A., M.D., F.F.P.S.G.,
 J.P., Dundrennan, 50 Queen Mary
 avenue, Crosshill. 1900
 aSmith, Robert B., 28 Glisson road,
 Cambridge. 1884
 aSmith, W.B., 34 Buchanan street. 1895
 aSmith, W. Robertson, 8 Windsor
 terrace, W. 1902
 Snodgrass, J. F., Ashbourne, Winton
 drive, Kelvininside. 1900
 835 Snodgrass, William, M.A., M.B.,
 C.M., F.F.P.S.G., 11 Victoria
 cres., Dowanhill. 1890
 Soddy, Frederick, M.A., Chemistry
 Department, Glasgow University. 1904
 aSomerville, Alex., B.Sc., F.L.S.,
 4 Bute mansions, Hillhead. 1888
 Speirs, William, Junr., Invershiel,
 Lenzie. 1905
 aSpencer, Charles L., Edgehill, Kel-
 vininside. 1891
 840aSpencer, J. J., Edgehill, Kelvininside. 1895

- Spens, John A., 169 West George street. 1879
- a*Steel, James, M.A., 502 St Vincent street. 1901
- a*Steel, William Strang, Philiphaugh, Selkirk. 1889
- a*Stephen, John, Domira, Partick. 1880
- 845 Sterling, John Lockhart, 92 Union street. 1901
- Steven, Henry, 35 College street. 1900
- Steven John, Eastvale place, Kelvinhaugh. 1875
- a*Stevenson, D. M., 12 Waterloo street. 1889
- Stevenson, John G., 147 St Vincent street. 1903
- 850 Stevenson, J. V., Dunacre, Beech avenue, Bellahouston. 1902
- Stevenson, Samuel, 4 Royal terrace, Crosshill. 1902
- Stevenson, William, 13 Carlton place. 1888
- Stewart, Allan Alfred, 180 Hope street. 1901
- Stewart, David, Noorlinn, Dunblane. 1859
- 855 Stewart, John, 220 Parliamentary road. 1899
- Stewart, Robert, Ellerslie, Partickhill. 1899
- a*Stewart, Robertson Buchanan, 146 Argyle street. 1901
- a*Stobo, Thomas, Somerset house, Garelochhead. 1884
- Stockdale, H. F., Clairinch, Upper Helensburgh. 1899
- 860 Stockman, Ralph, M.D., F.R.S.E., Professor of Materia Medica, The University of Glasgow. 1897
- Stoddart, James Edward, Howden, Mid-Calder, N.B. 1872
- Story, The Very Rev. R. H., D.D., Principal of the University of Glasgow. 1899
- Strachan, George, Fairfield Works, Govan. 1900
- a*Strain, James M., 15 Kingsborough gardens, W. 1900
- 865 *a*Strain, John, C.E., Cassilis House, Maybole, Ayrshire. 1876
- Strathie, David, C.A., 162 St Vincent street. 1895
- a*Sutherland, David, Balmaccara Hotel, Lochalsh. 1880
- a*Sutherland, John, Columba Hotel, Oban. 1880
- Sutherland, J. R., C.E., 45 John street. 1884
- 870 Swan, Charles C., 30 Renfield street. 1891
- Tait, William, 2 Knowe terrace, Pollokshields. 1902
- Tatlock, John, F.I.C., 13 Parkgrove terrace, West, Sandyford. 1875
- Tatlock, Robert R., F.R.S.E., F.I.C., F.C.S., 156 Bath street. 1868
- Taylor, Benjamin, F.R.G.S., 10 Derby crescent, Kelvinside. 1872
- 875 *a*Teacher, John H., M.B., C.M., 32 Kingsborough gardens, Dowanhill. 1898
- Templeton, James, 2 Claremont terrace. 1900
- Templeton, John Stewart, William street, Calton. 1900
- Tennant, Alexander, Bothwell Bank, Bothwell. 1905
- Tennant, Sir Charles, Bart, 175 West George street. 1868
- 880 *a*Tennent, Gavin P., M.D., 159 Bath street. 1875
- Thomas, Moses, M.D., 27 Buchanan Drive, Rutherglen. 1890
- a*Thomson, Edward J., Western Club. 1904
- Thomson, Gilbert, M.A., C.E., 164 Bath street. 1885
- Todd, John Aiton, B.L., 190 West George street. 1897
- 885 Townsend, C. W., Crawford street, Port-Dundas. 1890
- Trotter, Alexander M., M.R.C.V.S., Moore street. 1902
- Trotter, John, 40 Gordon street. 1899
- a*Tullis, James Thomson, Aytoun, Sydenham road, Dowanhill. 1883
- a*Tullis, John, John street, Bridge-ton. 1900
- 890 Turpie, John, 420 Sauchiehall street. 1896
- Ure, William P., Balvaird, Helensburgh. 1893
- Vaughan, J., 7 Campside crescent, Langside. 1902
- a*Waddell, Robert Davidson, Rednock, Kelvinside, W. 1901
- Walker, Adam, 2 Newton place. 1880
- 895 *a*Walker, Alexander, City Chambers. 1903
- a*Walker, Archibald, M.A.(Oxon.), F.I.C., F.C.S., 7 Crown terrace, Dowanhill. 1858
- Walker, J. W. O., 12 The Polygon, Eccles., Manchester. 1896
- a*Walker, William H., Cardarroch House, Airdrie. 1900
- Wallace, James Wilson, M.D., C.M., Cairnsmore, 67 St Andrew's drive, Pollokshields. 1900
- 900 Wallace, William, M.A., LL.D., barrister-at-law, 42 Athole gardens, Dowanhill. 1900
- a*Walker, Hugh, M.A., M.B., C.M., 52 Kilmarnock road, Shawlands. 1903

- Walker, James A., 206 Bath street. 1898
 aWallace, Wm., M.A., M.B., C.M., 25 Newton place. 1888
 aWardlaw, Alex., The Clydesdale Bank, Ltd. 1900
 905 Warren, John A., C.E., 94 Hope st. 1887
 Watson, Archibald, 9 Montgomerie drive, Kelvinside. 1881
 Watson, Harold, 9 Holland place. 1901
 Watson, James, 6 Kirklee road, Kelvinside, W. 1873
 Watson, John, National Bank, Crosshill. 1900
 910 Watson, Joseph, Chappell, Barrhead. 1882
 aWatson, J. Robertson, M.A., Professor of Chemistry, Anderson's College Medical School, Dumfries road. 1891
 aWatson, Thomas Lennox, I.A., F.R.I.B.A., 166 Bath street. 1876
 aWeir, James, 72 St Andrew's drive, Pollokshields. 1902
 aWeir, William, Shewalton, Dreg-horn. 1901
 915 Welsh, John M., Ph.D., F.E.I.S., F.R.G.S., 17 Brownlie street, Mount Florida. 1897
 White, John, Scotstoun Mills, Partick. 1897
 aWhitson, Jas. M.D., F.F.P.S.G., Blairgowrie. 1882
 Whyte, A. C., L.D.S., 42 Dundas street. 1892
 Wield, John, 9 Barns street, Ayr. 1895
 920 Wilkie, Daniel, 53 Bothwell street. 1906
 Williams, Alexander Malcolm, M.A., Church of Scotland Training College. 1903
 Williamson, John, 65 West Regent street. 1881
 aWatson, William W., 5 Westbourne terrace. 1899
 Watt, Alexander, 183 St Vincent street. 1900
 925 Webster, H. Carvick, 48 Montgomerie drive. 1900
 Wilson, Alex., Hyde Park Foundry, 54 Finnieston street. 1874
 aWilson, David, M.A., D.Sc., F.C.S., Carbeth, Killearn. 1898
 Wilson, Thomas F., 163 Hope st. 1901
 Wilson, Thomas, 119 Finsbury Pavement, London, c/o Thos. Brown & Sons, Ltd. 1902
 930 Wilson, Walter Stuart, 4 St John's terrace. 1901
 Wilson, Wm, F.E.I.S., School-house, Pavenham, Bedford. 1889
 Wingate, Arthur, Broomcraig, Largs. 1882
 Wingate, Walter E., 4 Bowmont ter. 1880
 Wood, Adam, Portland villa, Troon. 1901
 935 Wood, James, Dunard Street Public School, 23 Cranworth st., Hillhead. 1900
 Wood, James, M.A., Glasgow Academy. 1885
 aWood, William James, 266 George street. 1893
 Woodrow, Alexander, 75 Glassford street. 1900
 Woodrow, Alexander Norie, 75 Glassford street. 1900
 940a Workman, Chas, M.D., F.F.P., & S.G., Professor of Pathology, St Mungo's College, 5 Woodside ter. 1898
 Wright, Robert Patrick, Professor of Agriculture, West of Scotland Agricultural College, 6 Blythswood square. 1895
 Wylie, William A., 13 Woodside ter. 1901
 Wyllie, Archibald D., 1 Minard terrace, Partickhill. 1905
 Wyper, James, Nithsdale Lodge, Pollokshields. 1900
 945 Yellowlees, D., M.D., LL.D., 6 Albert gate. 1881
 Young, Frank W., H.M. Inspector of Schools, 32 Buckingham ter. 1902
 aYoung, James, jun., Caerleon, Bearsden. 1900
 aYoung, John E., 24 Belhaven ter, Kelvinside. 1900
 Young, John, 8 Athole gardens, Hillhead. 1900
 950 Young, John, 2 Montague terrace, Kelvinside. 1885
 aYoung, John, M.A., B.Sc., 28 Bank street, Hillhead. 1887
 Young, John Ross, 65 Bath street. 1903
 Young, John, 42 Bath street.
 Yuill, John Weir, Glenmillhouse, Campsie Glen. 1901

INDEX.

- Acuteness, visual, table of, 95, 96, 97.
Adam, Dr Alexander, grammarian, 177, 180, 187.
Adamnan, abbot of Iona, 16.
Additions to the Library, 267-272.
Agreement with the Engineers, 241, 246.
Air, in public halls, 65; in workshops, 63.
Algeria, beasts of burden in, 5; railway journey in, 3.
Allan, Dr G. E., on the Magnetic Properties of some Minerals, 258.
Alloys, Heusler's magnetic, 125.
Amours, F. J., on Saint Serf's Priory in Lochleven, 15.
Anderson, Andrew, printer in Edinburgh and Glasgow, 142.
Anthropometry, and its bearing on eyesight, 114.
Arabs in a railway carriage, 3.
Architectural Section, Office-bearers of, 264.
Ardmore, granted to the Keledei, 20.
Argon, existence of, foreshadowed, 38; discharge through, 42; Early observations connected with, 38; Origin of the name, 40.
Army, the, contribution of, to Human Wasteage, 80; and unskilled labour, 81; as a profession, 90; workshops in, 89.
Astigmatism, 107.
Atmosphere, constituents of the, 59; inactive gases of the, 38.
Attraction between two concentric thin hemispherical shells of matter, 195.
Attraction of Ellipsoidal shells and of Solid Ellipsoids at External and Internal points, 208.
Attractive force between two halves of a sphere of matter, 192.
Barclay, Alexander, 160.
Barr, James, grammarian, 185.
Becker, Professor L., 241.
Beggars in Germany, 33.
Biological Section, Office-bearers of, 264.
Bird's, Hinckes, ventilator, 67.
Blau, Robert, 181.
Blyth, Professor James, on the Experimental Bases of some Theories in Electricity, 261.
Boniface, Saint, 17.
Books, donors of, thanked, 247.
Books, list of, referred to in decret of Privy Council, 1672, 145.
Brossier, Marthe, (the contortionist), 170.
Bruce Murray, Bailie John, on Social Reformation of Criminals, 46.
Brude, King of the Picts, 18.
Buno, Johann, 159.
Burgoine, Sir Robert of, 20.
Camel, description of the, 5.
Campbell, John F., appointed Auditor, 262.
Canons, priory of, founded at St. Andrews, 21.
Carmichael, Dr Neil, on the Necessity for Improved Ventilation of Buildings, 59.
Carson, Dr A. R., grammarian, 185.
Charity, indiscriminate, at Elberfeld, 35.
Charles' theorem, 211.
Chloromyxum leydigi, 76.
Clarke, John, grammarian, 179.
Classics, the, Editors of, (see grammarians).
Colines, Simon de, printer, 153.
Commissionaires, corps of, 87.
Committees of the Council, 266.
Conicoids, confocal, Gray's property of, 216.
Copland, Dr, death of, 241.
Council, Members of, 263; report of, 243.
Crawford, Hugh or Hugo, grammarian, 177, 180.
Criminals, Social Reformation of, 46; discussion, 260.
Dansen, John, death of, 241.
Decreet of Privy Council regarding printing, 1672, 145.
Derelicts, Social, 80.
Despauter's books, 149-173.
Donations to the Library, 267-270.
Donatus Minor, 151.
Drunkness and imprisonment, 50.
Dunbar's *Rudiments*, 173.
Eclipse of the Sun (1905), Expedition to observe the, 1; apparatus used, 4, 6; taking observations, 4, 8, 9, 11.
Economic Science Section, Office-bearers of, 265.
Economics, social, practical school of, 36.
Elberfeld System of Poor Relief, by Rev. Andrew Miller, 29.
Ellipsoidal shells, attraction of, at any point, 208.
Ellipsoids, attraction of, at any point, 208.
Emmetropia, 100.

- Exchanges with other Societies, 272-279.
 Extraordinary Meetings, 245, 255.
 Eyesight, affected by buildings and lighting, 115; affected by desks and posture, 115; affected by reading and writing, 116; affected by time of study and recreation, 119; and anthropology, 114; and face rests, 118; and heredity, 113; and sewing, 118; and home-work for children, 120; medical inspection of, in schools, 123; of school children, 93.
 Fergus, Dr Freeland, re-elected Honorary Secretary, 262.
 Fian, John, schoolmaster, burnt for witchcraft, 183.
 Finance Committee, 266.
 Fines, deduction from, during imprisonment, 49.
 Focaloid, thick, potential at any point, due to, 236.
 Folding, lines of, in the Highland Schists, 129.
 French, Edward, on A Simple Gas Volumeter, 256.
 Gairdner, C. D., thanked by Society, 247.
 Gases, atomic state of, in the Sun, 44; inactive, of the atmosphere, 38.
 Gauss, theorem of, applied to attraction between two halves of a sphere of matter, 205.
 Gender (Latin) rules in verse, 179.
 Geographical and Ethnological Section, Office-bearers of, 265.
 Glasgow, early grammars and other school books in use in, 142; five-year course in the Grammar School of, 174; University "Eclipse" Expedition, 1.
 Gordon, William (Grammaticus?), 189.
 Graham Medal, Rules governing the competition for, 240.
 Graham Medal Fund, etc., Committee, 266.
 Grammarians and Editors of the Classics:—
 Adam, Dr Alexander, 177, 187; Aventinus, Joannes, otherwise Johann Thurnmaier, 152; Bachacziek, Martin, 156; Barr, James, 185; Blau, Robert, 181; Brown, Robert, 177; Buno, Johann, 159; Clyde, Dr James, 191; Colet, Dean, 155; Crawford, Hugh, 177; Despauter, John, 149-173; Dykes, Patrick, 173; Dymock, John, 190; Dymock, Thomas, 191; Farnaby, Thomas, 157; Heinrichmann, Jacob, 152; Horst, Peter, 170; Hunter, Dr John, 191; Kirkwood, James, 177; Lefèvre, Tanne-guy, or Tannaquillus Faber, 154; Mair, John, 185; Meganck, or Megang, Pierre, 154; Melanchthon, 156; Moir, James, 177, 189; Mummellius, Johannes, 153; Pinhel, or Pinelli, Duarte, 155; Pincianus, Johann, 169; Port Royalists, 178; Purdie, James, 181; Ramée, Pierre la, or Petrus Ramus, 156; Ruddiman, Thomas, 188; Schottenn, Hermann, 158; Sinclair, James, 184; Sulpicius, Joannes, 152; Torrentin, Hermann (Van Beeck), 160; Turner, William, 184; Verger, Eloy, 157; Voss, John Gerard, 175; Wolsey, Cardinal, 155.
 Grammars and other School Books in use in Scotland, 142.
 Grammar School of Glasgow, five-year course in, 174.
 Grammaticus' essay on the teaching of Latin, 189.
Grammaticus and *grammatista*, distinction between, 163.
 Grammatographia, 153.
 Gray, J. G., on Heusler's Magnetic Alloys, 125.
 Gray, Professor Andrew, on Solutions of Physical Problems, 192.
 Gray's property of confocal conicoids, 216.
 Green, George (note on), 227.
 Gunn, N. B., thanked by Society, 247.
 Hæmosporidia, 74.
 Halls, arrangement for ventilating, 69; public, air in, 65.
 Hemispherical shells of matter, attraction between two concentric thin, 195.
 Henderson, Professor G. G. (lecture) "With the British Association in South Africa," 259.
 Heredity and eyesight, 113.
 Heusler's Magnetic Alloys, by J. G. Gray, 125.
 Hinkes Bird's ventilator, 67.
 Historical and Philological Section, Office-bearers of, 265.
 Hospitals, ventilation of, 66, 70.
 House Committee, 266.
 Human Wastage, contribution of the Army to, 80.
 Hunter, Dr John, Editor of Classics, 191.
 Hypermetropia, 102.
 Imprisonment for short terms, 49; in Scotland in 1903, 50; and drunkenness, 50.
 Improved Ventilation of Buildings, the Necessity for, 59.
 Income, subsidising of, in Elberfeld, 34.
 Ivory's theorem, 209.
 Kalaa es Senam, 11.
 Keledei, the, 18; possessions of, 21.
 Kirkness given to the Keledei, 19; granted to Peter de Campana, 23.
 Labour, unskilled, and the Army, 81.
 Lefèvre, Tanne-guy, 154.
Leptotheca agilis Thel, 76.
 Library, the, additions to, 267-272; books presented to, 267-270; books purchased for, 270-272; Committee, 266; when open, 282.

- Lloyd, Dr R. J., on Advantages of the Study and Acquisition of Esperanto, 261.
 Lochleven, Saint Serf's Priory in, 15.
- Macbeth, son of Finlach, 19.
 M'Iroy, Dr Janie Hamilton, on Some Notes on the leaves of *Nephrodium Filix Mas. L.*, and *Scolopendrium Vulgare Sm.*, in relation to Environment, 136.
 Maclaurin, Colin (note on), 226.
 Macnair, Peter, on the development of the Great Axial Lines of Folding in the Highland Schists, 129.
 "Magistratis," allowance for dedicating a book to the, in 1662, 148.
 Magnetic Alloys, Heusler's, 125.
 Mair, John, grammarian, 185.
 Malduin, bishop of St. Andrews, 19.
 Mann, John, re-elected Hon. Treasurer, 262.
 Mann, John, jun., elected Vice-President, 262.
 Markinch granted to the Keledei, 19.
 Mathematical and Physical Section, Office-bearers of, 265.
 Mavor, Henry A., account of the Glasgow University Eclipse Expedition, 1905, 1.
 Maxwell, Sir John Stirling, Bart., elected Member of Council, 262.
 Medley, Professor Dudley J., re-elected Member of Council, 262.
 Meganck, Pierre, 154.
 Members of the Society—Honorary, 283; Corresponding, 284; Ordinary, 284-299.
 New :—
 Aiken, James, 253.
 Anderson, William J., 259.
 Bannatyne, Mark, 253.
 Boyd, James, 242.
 Brock, Henry, 253.
 Campbell, M. Pearce, 253.
 Carson, D. S., 242.
 Carrick, John, 253.
 Clapperton, Alan E., 242.
 Coats, Sir Thomas Glen, Bart., 242.
 Colville, Archibald, 253.
 Colville, David, 254.
 Cooper, David, 242.
 Currie, John, 254.
 Davidson, David, 254.
 Davie, Alexander, 259.
 Ellis, David, 254.
 Ferguson John A., 257.
 Fyfe, John W., 242.
 Gibson, James, 256.
 Gillies, H. F., 254.
 Gordon, H. E., 259.
 Grieve, W. Weir, 254.
 Guy Robert, 254.
 Hedley, H. A., 242.
 Henderson, Andrew, 261.
 Hill, Thomas N., 242.
 Inverclyde, Lord, 254.
 Jack, George, 255.
 Kedie, Robert, 242.
 Kidston, J. B., 254.
 King, Robert, 242.
 Lackie, W. W., 254.
 Law, A. Bonar, 243.
 Lawrie, Sir Archibald C., 242.
 Lipton, Sir Thomas J., Bart., 254.
 Lobban, William, 242.
 Lumsden, James, 242.
 M'Connachie, John, 254.
 Macfee, John, 242.
 Macgeorge, B. B., 254.
 Mackendrick, Alexander, 243.
 Mackenzie, Robert, 243.
 Mackintosh, Walter, 254.
 Main, James, 243.
 Maxwell, Sir John Stirling, Bart., 254.
 Mellanby, A. L., 243.
 Murdoch, Alexander, 254.
 Murray, A. S., 243.
 Murray, R. A., 243.
 Nicol, William Smith, 256.
 Nicolson, W. B., 259.
 Nisbet, John, 243.
 Overtoun, Lord, 259.
 Prentice, Thomas, 257.
 Rennie, Thomas, 254.
 Rottenburg, Fritz, 243.
 Sloan, William, 254.
 Speirs, William, 255.
 Tennant, Alexander, 255.
 Wilkie, Daniel, 261.
 Wyllie, Archibald D., 243.
- Miller, James N., on Methods of trisecting an angle, etc., 258.
 Miller, Rev. Andrew, on the Elberfeld system, 29.
 Minutes of Session, 241.
 Montrose, Robert of, assassinated, 24.
 Monypenny, Walter, prior of Lochleven, 27.
 Moray, Regent, made prior, 28.
 Muir, Robert, 183.
 Murellius, Johannes, 153.
 Murray, Bailie John Bruce, on Social Reformation of Criminals, 46.
 Murray, Dr David, on some early Grammars and other School Books in use in Scotland, 142.
 Murray, Dr Erskine, 241.
 Myopia, 102, 109; tables of, 106, 108; diagram of, 110; prevention of, 114; table of percentage of, among pupils in Sweden, 122.
Myxidium sp., 76.
 Myxosporidia, 74.
- Navathy, Stanry Furde of, 24.
 Near-work, as affecting eyesight, 112.
 Neilson, James, appointed Auditor, 262.
Nephrodium Filix Mas. L., 136.
 New Members (see Members).

- Novimola's abridgment of Despauter, 142-191, *passim*.
- Offenders, Probation of First, Act, 52, 53.
- Office-bearers of the, Sections, 264, 265; Society, 263.
- Omer Talon, or Andomarus Talaëus, grammarian, 177.
- Papers, Committee on, 266.
- Parasitic protozoa, certain, 74.
- Periodicals in the Reading-room, 280-282.
- Philippeville, 2.
- Physical Problems, Solutions of, 192.
- Physiology and Ventilation, 72.
- Plenum system, defects of, 71.
- Pollock, Dr W. B. Inglis, on the Eyesight of School Children, 93.
- Port Royal Latin Grammar, 178.
- Prestonpans Grammar School, 183.
- Probation of First Offenders Act, 52, 53; " Guardianship, 53.
- Problems, Physical, solutions of, 192.
- Protozoa, certain parasitic, 74.
- Purdie, James, grammarian, 181.
- Purdie, Wm. Gavin, elected to Membership, 262.
- Pythonis, Trypanosoma*, 74.
- Ramsay, Sir William, on the Inactive Gases of the Atmosphere, 38.
- Rates, poor, ex-soldiers chargeable to, 83.
- Reformation, Social, of Criminals, 46.
- Refraction, errors of, 111; table, 103; diagram, 104.
- Reports, of Council, 243; of Library Committee, 245.
- Robertson, John, re-elected Hon. Librarian, 262.
- Robertson, Muriel, on certain parasitic protozoa from the groups of the Myxosporidia and Hæmosporidia, 74.
- Ruddiman, Thomas, grammarian, 178.
- Ruddiman's *Rudiments*, 189, 190.
- Saint Serf's Priory in Lochleven, by F. J. Amours, 15.
- Samuel, John S., on Social Derelicts; or the Contribution of the Army to Human Waste, 80.
- Sanders, Robert, printer in Glasgow, 143-148.
- Sanitary and Social Economy Section, Office-bearers of, 364.
- Schists, Highland, development of the Great Axial Lines of Folding in the, 129.
- School Books-in use in Scotland, 142.
- School Children, Eyesight of, 93.
- Science Lecture Trust, etc., Committee, 266.
- Scolopendrium vulgare Sm.*, 139.
- Scots, meanings of some Latin words in, 171.
- Sections, Office-bearers of the, 264, 265.
- Serf's, Saint, documents relating to, 24.
- Servan's canons, restoration of endowments, 23.
- Servanus, or Saint Servan, 15.
- Shells of matter, attraction between two concentric thin hemispherical, 195.
- Snodgrass, Dr William, re-elected Member of Council, 262.
- Social Derelicts, 80.
- Social Reformation of Criminals, by Bailie John Bruce Murray, 46.
- Society, the, Office-bearers of, 263.
- Soldiers and Sailors Help Society, 87.
- Soldiers, ex-, in receipt of poor relief, 83; reports of Select Committee on, 86; employed in public departments, and by railway companies, 85; of doubtful fitness for ordinary occupations, 88.
- Some Facts and Theories connected with the Inactive Gases of the Atmosphere, by Sir W. Ramsay, 38.
- Spectacles, 120.
- Sphere of matter, attractive force between two halves of a, 192.
- Sulpicius, Joannes, 152.
- Sun, its reserve of heat, 45.
- Talon, Omer, grammarian, 177.
- Theatres, purity of air in, 64.
- Todd, John A., re-elected Member of Council, 262.
- Tran, John, 181.
- Treasurer's Abstracts of Accounts, 248-252.
- Trypanosoma pythonis*, 74.
- Ventilation, good, how secured, 66; and Physiology, 72; of buildings, the necessity for improved, 59; of halls, 69; of hospitals, 66; of workshops, churches, etc., 68.
- Ventilator, Hinkes Bird's, 67.
- Visual Acuteness, 94; tables of, 95, 96, 97.
- Voss, Gerard John, "the Prince of Grammarians," 175.
- Voss, rhetoric of, 174.
- Wastage, Human, contribution of the Army to, 80.
- Watt, Thomas, grammarian, 178.
- Workshops, purity of air in, 63.
- Wynrame, John, the last prior of St. Serf's, 28.
- Wyntoun, Andrew, 24, 25, 26, 27.



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